FUJITSU SEMICONDUCTOR
CONTROLLER MANUAL

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F²MC-16 FAMILY

SOFTUNE™ Workbench

USER'S MANUAL

FUJITSU

F^2MC-16 FAMILY

SOFTUNE™ Workbench

USER'S MANUAL

FUJITSU SEMICONDUCTOR LIMITED

PREFACE

■ What is the SOFTUNE Workbench?

SOFTUNE Workbench is support software for developing programs for the F^2MC-16 family of microprocessors / microcontrollers.

It is a combination of a development manager, simulator debugger, emulator debugger, monitor debugger, and an integrated development environment for efficient development.

■ Purpose of this manual and target readers

This manual explains functions of SOFTUNE Workbench.

This manual is intended for engineers designing several kinds of products using SOFTUNE Workbench.

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■ Organization of This Manual

This manual consists of the following 2 chapters.

CHAPTER 1 BASIC FUNCTIONS

This chapter describes the basic functions on the SOFTUNE Workbench.

CHAPTER 2 DEPENDENCE FUNCTIONS

This chapter describes the functions dependent on each Debugger.

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READING THIS MANUAL

■ Configuration of Page

In each section of this manual, the summary about the section is described certainly, so you can grasp an outline of this manual if only you read these summaries.

And the title of upper section is described in lower section, so you can grasp the position where you are reading now.

CONTENTS

CHAPTER 1

BASIC FUNCTIONS

This chapter describes the basic functions on the SOFTUNE Workbench.

1.1 Workspace Management Function

This section explains the workspace management function of SOFTUNE Workbench.

■ Workspace

SOFTUNE Workbench uses workspace as a container to manage two or more projects including subprojects.

For example, a project that creates a library and a project that creates a target file using the project can be stored in one workspace.

■ Workspace Management Function

To manage two or more projects, workspace manages the following information:

- Project
- Active project
- Subproject

■ Project

The operation performed in SOFTUNE Workbench is based on the project. The project is a set of files and procedures necessary for creation of a target file. The project file contains all data managed by the project.

■ Active Project

The active project is basic to workspace and undergoes [Make], [Build], [Compile/Assemble], [Start Debug], and [Update Dependence] in the menu. [Make], [Build], [Compile/Assemble], and [Update Dependence] affect the subprojects within the active project.

If workspace contains some project, it always has one active project.

■ Subproject

The subproject is a project on which other projects depend. The target file in the subproject is linked with the parent project of the subproject in creating a target file in the parent project.

This dependence consists of sharing target files output by the subproject, so a subproject is first made and built. If making and building of the subproject is unsuccessful, the parent project of the subproject will not be made and built.

The target file in the subproject is however not linked with the parent project when:

- An absolute (ABS)-type project is specified as a subproject.
- A library (LIB)-type project is specified as a subproject.

■ Restrictions on Storage of Two or More Projects

Only one REALOS-type project can be stored in one workspace.

1.2 Project Management Function

This section explains the project management function of SOFTUNE Workbench.

■ Project Management Function

The project manages all information necessary for development of a microcontroller system. Especially, its major purpose is to manage information necessary for creation of a target file.

The project manages the following information:

- Project configuration
- Active project configuration
- Information on source files, include files, other object files, library files
- Information on tools executed before and after executing language tools (customize build function)

■ Project Format

The project file supports two formats: a 'workspace project format,' and an 'old project format.'

The differences between the two formats are as follows:

Workspace project format

- Supports management of two or more project configurations
- Supports use of all macros usable in manager
- Does not support early Workbench versions(*)

Old project format

- Supports management of just one project configuration
- Limited number of macros usable in manager
  For details, see Section "1.11 Macro Descriptions Usable in Manager".
- Supports early Workbench versions(*)

When a new project is made, the workspace project format is used.

When using an existing project, the corresponding project format is used.

If a project made by an early Workbench version(*) is used, a dialog asking whether to convert the file to the workspace project format is displayed. For details, refer to Section "2.13 Reading SOFTUNE Project Files of Old Versions" of "SOFTUNE Workbench Operation Manual".

To open a project file in the workspace project format with an early Workbench version(*), it is necessary to convert the file to the old project format. For saving the file in other project formats, refer to Section "4.2.7 Save As" of "SOFTUNE Workbench Operation Manual".

*: F^2MC-16: V30L26 or earlier

■ Project Configuration

The project configuration is a series of settings for specifying the characteristics of a target file, and making, building, compiling and assembling is performed in project configurations.

Two or more project configurations can be created in a project. The default project configuration name is Debug. A new project configuration is created on the setting of the selected existing project configuration. In the new project configuration, the same files as those in the original project configuration are always used.

By using the project configuration, the settings of programs of different versions, such as the optimization

level of a compiler and MCU setting, can be created within one project.

In the project configuration, the following information is managed:

- Name and directory of target file
- Information on options of language tools to create target file by compiling, assembling and linking source files
- Information on whether to build file or not
- Information on setting of debugger to debug target file

■ Active Project Configuration

The active project configuration at default undergoes [Make], [Build], [Compile/Assemble], [Start Debug], and [Update Dependence].

The setting of the active project configuration is used for the file state displayed in the SRC tab of project window and includes files detected in the Dependencies folder.

Note:

If a macro function newly added is used in old project format, the macro description is expanded at the time of saving in old project format. For the macro description newly added, refer to Section "1.11 Macro Descriptions Usable in Manager".

1.3 Project Dependence

This section explains the project dependence of SOFTUNE Workbench.

■ Project Dependence

If target files output by other projects must be linked, a subproject is defined in the project required in [Project] - [Project Dependence] menu. The subproject is a project on which other projects depend.

By defining project dependence, a subproject can be made and built to link its target file before making and building the parent project.

The use of project dependence enables simultaneous making and building of two or more projects developed in one workspace.

A project configuration in making and building a subproject in [Project] - [Project Configuration] - [Build Configuration] menu can be specified.

1.4 Make/Build Function

This section explains the make/build function of SOFTUNE Workbench.

■ Make Function

Make function generates a target file by compiling/assembling only updated source files from all source files registered in a project, and then joining all required object files.

This function allows compiling/assembling only the minimum of required files. The time required for generating a target file can be sharply reduced, especially, when debugging.

For this function to work fully, the dependence between source files and include files should be accurately grasped. To do this, SOFTUNE Workbench has a function for analyzing include dependence. To perform this function, it is necessary to understand the dependence of a source file and include file. SOFTUNE Workbench has the function for analyzing the include file dependence. For details, see Section "1.5 Include Dependencies Analysis Function".

■ Build Function

Build function generates a target file by compiling/assembling all source files registered with a project, regardless of whether they have been updated or not, and then by joining all required object files. Using this function causes all files to be compiled/assembled, resulting in the time required for generating the target file longer. Although the correct target file can be generated from the current source files.

The execution of Build function is recommended after completing debugging at the final stage of program development.

Note:

When executing the Make function using a source file restored from backup, the integrity between an object file and a source file may be lost. If this happens, executing the Build function again.

1.4.1 Customize Build Function

This section describes the SOFTUNE Workbench to set the Customize Build function.

■ Customize Build function

In SOFTUNE Workbench, different tools can be operated automatically before and after executing the Assembler, Compiler, Linker, Librarian, Converter, or Configurator started at Compile, Assemble, Make, or Build.

The following operations can be performed automatically during Make or Build using this function:

- starting the syntax check before executing the Compiler,
- after executing the Converter, starting the S-format binary Converter (m2bs.exe) and converting Motorola S-format files to binary format files.

■ Setting Options

An option follows the tool name to start a tool from SOFTUNE Workbench. The options include any file name and tool-specific options. SOFTUNE Workbench has the macros indicating that any file name and tool-specific options are specified as options.

If any character string other than parameters is specified, it is passed directly to the tool. For details about the parameters, see Section "1.11 Macro Descriptions Usable in Manager".

■ Macro List

The Setup Customize Build dialog provides a macro list for macro input. The build file, load module file, project file submenus indicate their sub-parameters specified.

The environment variable brackets must have any item; otherwise, resulting in an error.

Table 1.4-1 Macro List

Macro List	Macro Name
Build file	%(FILE)
Load module file	%(LOADMODULEFILE)
Project file	%(PRJFILE)
Workspace file	%(WSPFILE)
Project directory	%(PRJPATH)
Target file directory	%(ABSPATH)
Object file directory	%(OBJPATH)
List file directory	%(LSTPATH)
Project construction name	%(PRJCONFIG)
Environment variable	%(ENV[])
Temporary file	%(TEMPFILE)

Note:

When checking [Use the Output window], note the following:

- Once a tool is activated, Make/Build is suspended until the tool is terminated.
- The Output window must not be used with a tool using a wait state for user input while the tool is executing. The user can not perform input while the Output window is in use, so the tool cannot be terminated. To forcibly terminate the tool, select the tool on the Task bar and input Control - C, or Control - Z.

1.5 Include Dependencies Analysis Function

This section describes the function of the Include Dependencies Analysis of SOFTUNE Workbench.

■ Analyzing Include Dependencies

A source file usually includes some include files. When only an include file has been modified leaving a source file unchanged, SOFTUNE Workbench cannot execute the Make function unless it has accurate and updated information about which source file includes which include files.

For this reason, SOFTUNE Workbench has a built-in Include Dependencies Analysis function. This function can be activated by selecting the [Project] - [Include Dependencies] menu. By using this function, uses can know the exact dependencies, even if an include file includes another include file.

SOFTUNE Workbench automatically updates the dependencies of the compiled/assembled files.

Note:

When executing the [Project] - [Include Dependencies] menu, the Output window is redrawn and replaced by the dependencies analysis result.

If the contents of the current screen are important (error message, etc.), save the contents to a file and then execute the Include Dependencies command.

1.6 Functions of Setting Tool Options

This section describes the functions to set options for the language tools activated from SOFTUNE Workbench.

■ Function of Setting Tool Options

To create a desired target file, it is necessary to specify options for the language tools such as a compiler, assembler, and linker. SOFTUNE Workbench stores and manages the options specified for each tool in project configurations.

Tool options include the options effective for all source files (common options) and the options effective for specific source files (individual options). For details about the option setting, refer to Section "4.5.5 Setup Project" of "SOFTUNE Workbench Operation Manual".

- Common options
  These options are effective for all source files (excluding those for which individual options are specified) stored in the project.
- Individual options
  These options are compile/assemble options effective for specific source files. The common options specified for source files for which individual options are specified become invalid.

■ Tool Options

SOFTUNE Workbench the macros indicating that any file name and directory name are specified as options.

If any character string other than parameters is specified, it is passed directly to the tool. For details about the parameters, see Section "1.11 Macro Descriptions Usable in Manager". For details about the tool options for each tool, see the manual of each tool.

1.7 Error Jump Function

This section describes the error jump function in SOFTUNE Workbench.

■ Error Jump Function

When an error, such as a compile error occurs, double-clicking the error message displayed in the Output window, opens the source file where the error occurred, and automatically moves the cursor to the error line. This function permits efficient removal of compile errors, etc.

The SOFTUNE Workbench Error Jump function analyzes the source file names and line number information embedded in the error message displayed in the Output window, opens the matching file, and jumps automatically to the line.

The location where a source file name and line number information are embedded in an error message, varies with the tool outputting the error.

An error message format can be added to an existing one or modified into an new one. However, the modify error message formats for pre-installed Fujitsu language tools are defined as part of the system, these can not be modified.

A new error message format should be added when working the Error Jump function with user register. To set Error Jump, execute the [Setup] - [Error Jump Setting] menu.

■ Syntax

An error message format can be described in Syntax. SOFTUNE Workbench uses macro descriptions as shown in the Table 1.7-1 to define such formats.

To analyze up to where %f, %h, and %* continue, SOFTUNE Workbench uses the character immediately after the above characters as a delimiter. Therefore, in Syntax, the description until a character that is used as a delimiter re-appears, is interpreted as a file name or a keyword for help, or is skipped over. To use % as a delimiter, describe as %%. The %[char] macro skips over as long as the specified character continues in parentheses. To specify "]" as a skipped character, describe it as "\]". Blank characters in succession can be specified with a single blank character.

Table 1.7-1 List of Special Characters String for Analyzing Error Message

Characters	Semantics
%f	Interpret as source file name and inform editor.
%l	Interpret as line number and inform editor.
%h	Become keyword when searching help file.
%*	Skip any desired character.
%[char]	Skip as long as characters in [ ] continues.

[Example]

```
***   %f(%l)   %h: or, %[*]   %f(%l)   %h:
```

The first four characters are "*** ", followed by the file name and parenthesized page number, and then the keyword for help continues after one blank character.

This represents the following message:

```
***C :\Sample\sample.c(100)   E4062C:  Syntax Error:  near /int.
```

■ Reference Section

Setup Error Jump

1.8 Editor Functions

This section describes the functions of the SOFTUNE Workbench built-in standard editor.

■ Standard Editor

SOFTUNE Workbench has a built-in editor called the standard editor. The standard editor is activated as the Edit window in SOFTUNE Workbench. As many Edit windows as are required can be opened at one time.

The standard editor has the following functions in addition to regular editing functions.

- **Keyword marking function in C/assembler source file**
  Displays reserved words, such as if and for, in different color
- **Error line marking function**
  The error line can be viewed in a different color, when executing Error Jump.
- **Bookmark setup function**
  A bookmark can be set on any line, and instantaneously jumps to the line. Once a bookmark is set, the line is displayed in a different color.
- **Ruler, line number display function**
  The Ruler is a measure to find the position on a line; it is displayed at the top of the Edit window. A line number is displayed at the left side of the Edit window.
- **Automatic indent function**
  When a line is inserted using the Enter key, the same indent (indentation) as the preceding line is set automatically at the inserted line. If the space or tab key is used on the preceding line, the same use is set at the inserted line as well.
- **Function to display, Blank, Line Feed code, and Tab code**
  When a file includes a Blank, Line Feed code, and Tab code, these codes are displayed with special symbols.
- **Undo function**
  This function cancels the preceding editing action to restore the previous state. When more than one character or line is edited, the whole portion is restored.
- **Tab size setup function**
  Tab stops can be specified by defining how many digits to skip when Tab codes are inserted. The default is 8.
- **Font changing function**
  The font size for character string displayed in the Edit window can be selected.

■ Reference Section

Edit Window (The Standard Editor)

1.9 Storing External Editors

This section describes the function to set an external editor to SOFTUNE Workbench.

■ External Editor

SOFTUNE Workbench has a built-in standard editor, and use of this standard editor is recommended. However, another accustomed editor can be used, with setting it, instead of an edit window. There is no particular limit on which editor can be set, but some precautions (below) may be necessary. Use the [Setup] - [Editor setting] menu to set an external editor.

■ Precautions

- **Error jump function**
  The error jump cannot move the cursor to an error line if the external editor does not have a function to specify the cursor location when activated the external editor.
- **File save at compiling/assembling**
  SOFTUNE Workbench cannot control an external editor. Always save the file you are editing before compiling/assembling.

■ Setting Options

When activating an external editor from SOFTUNE Workbench, options must be added immediately after the editor name. The names of file to be opened by the editor and the initial location of the cursor (the line number). can be specified. SOFTUNE Workbench has a set of special parameters for specifying any file name and line number, as shown in the Table 1.9-1. If any other character string are described by these parameters, such characters string are passed as is to the editor.

%f (File name) is determined as follows:

1. If the focus is on the SRC tab of Project window, and if a valid file name is selected, the selected file name becomes the file name.
2. When a valid file name cannot be acquired by the above procedure, the file name with a focus in the built-in editor becomes the file name.

%x (project path) is determined as follows:

1. If a focus is on the SRC tab of project window and a valid file name is selected, the project path is a path to the project in which the file is stored.
2. If no path is obtained, the project path is a path to the active project.

Also file name cannot be given double-quotes in the expansion of %f macros.

Therefore, it is necessary for you to provide double-quotes for %f. Depending on the editor, there are line numbers to which there will be no correct jump if the entire option is not given double-quotes.

Table 1.9-1 List of Special Characters for Analyzing Error Message

Parameter	Semantics
%%	Means specifying % itself
%f	Means specifying file name
%l	Means specifying line number
%x	Means specifying project path

■ Example of Optional Settings

Table 1.9-2 Example of Optional Settings

Editor name	Argument
WZ Editor V4.0	%f /j%l
MIFES V1.0	%f+%l
UltraEdit32	%f/%l/1
TextPad32	%f(%l)
PowerEDITOR	%f -g%l
Codewright32	%f -g%l
Hidemaru for Win3.1/95	/j%l:1 %f
ViVi	/line=%l %f

■ Reference Section

Editor Setup

Note:

Regarding execution of error jump in Hidemaru:
To execute error jump in Hidemaru used as an external editor, use the [Others] - [Operating Environment] - [Exclusive Control] menu, and then set "When opening the same file in Hidemaru" and "Opening two identical files is inhibited".

1.10 Storing External Tools

This section describes the function to set an external tool to SOFTUNE Workbench.

■ External Tools

A non-standard tool not attached to SOFTUNE Workbench can be used by setting it as an external tool and by calling it from SOFTUNE Workbench. Use this function to coordinate with a source file version control tool.

If a tool set as an external tool is designed to output the execution result to the standard output and the standard error output through the console application, the result can be specified to output the SOFTUNE Workbench Output window. In addition, the allow description of additional parameters each time the tool is activated.

To set an external tool, use the [Setup] - [Setting Tool] menu.

To select the title of a set tool, use the [Setup] - [Activating Tool] menu.

■ Setting Options

When activating an external tool from SOFTUNE Workbench, options must be added immediately after the external tool name. Specify the file names, and unique options, etc.

SOFTUNE Workbench has a set of special parameters for specifying any file name and unique tool options.

If any characters string described other than these parameters, such characters string are passed as is to the external tool.

For details about the parameters, see Section "1.11 Macro Descriptions Usable in Manager".

Note:

When checking [Use the Output window], note the following:

- Once a tool is activated, neither other tools nor the compiler/assembler can be activated until the tool is terminated.
- The Output window must not be used with a tool using a wait state for user input while the tool is executing. The user cannot perform input while the Output window is in use, so the tool cannot be terminated. To forcibly terminate the tool, select the tool on the Task bar and input Control - C, or Control - Z.

■ Reference Section

Setting Tools

Starting Tools

1.11 Macro Descriptions Usable in Manager

This section explains the macro descriptions that can be used in the manager of SOFTUNE Workbench.

■ Macros

SOFTUNE Workbench has special parameters indicating that any file name and tool-specific options are specified as options.

The use of these parameters as tool options eliminates the need for options specified each time each tool is started.

The type of macro that can be specified and macro expansion slightly vary depending on where to describe macros. The macros usable for each function are detailed below. For the macros that can be specified for "Error Jump" and "External Editors" see Sections "1.7 Error Jump Function" and "1.9 Storing External Editors".

■ Macro List

The following is a list of macros that can be specified in SOFTUNE Workbench.

The macros usable for each function are listed below.

- External tools: Table 1.11-1 and Table 1.11-2
- Customize build: Table 1.11-1 and Table 1.11-2
- Tool options: Table 1.11-2

The directory symbol \ is added to the option directories in Table 1.11-1 but not to the macro directories in Table 1.11-2.

The sub-parameters in Table 1.11-3 can be specified in %(FILE), %(LOADMOUDLEFILE), %(PRJFILE).

The sub-parameter is specified in the form of %(PRJFILE[PATH]).

If the current directory is on the same drive, the relative path is used. The current directory is the workspace directory for %(PRJFILE), and %(WSPFILE), and the project directory for other than them.

Table 1.11-1 List of Macros That Can Be Specified 1

Parameter	Meaning
%f	Passed as full-path name of file. (*1)
%F	Passed as main file name of file. (*1)
%d	Passed as directory of file. (*1)
%e	Passed as extension of file. (*1)
%a	Passed as full-path name of load module file.
%A	Passed as main file name of load module file. (*2)
%D	Passed as directory of load module file. (*2)
%E	Passed as extension of load module file. (*2)
%x	Passed as directory of project file. (*2)
%X	Passed as main file name of project file. (*2)
%%	Passed as %.

Table 1.11-2 List of Macros That Can Be Specified 2

Parameter	Meaning
%(FILE)	Passed as full-path name of file. (*1)
%(LOADMODULEFILE)	Passed as full-path name of load module file. (*2)
%(PRJFILE)	Passed as full-path name of project file. (*2)
%(WSPFILE)	Passed as full-path name of workspace file. (*3)
%(PRJPATH)	Passed as directory of project file. (*2)
%(ABSPATH)	Passed as directory of target file. (*2)
%(OBJPATH)	Passed as directory of object file. (*2)
%(LSTPATH)	Passed as directory of list file. (*2)
%(PRJCONFIG)	Passed as project configuration name. (*2) (*3)
%(ENV [Environment variable])	Environment variable specified in environment variable brackets is passed.
%(TEMPFILE)	Temporary file is created and its full-path name is passed. (*4)

The macros in (*1) are determined as follows:

- Customize build
  1. Source file before and after executing compiler and assembler
  2. Target file before and after executing linker, librarian and converter
  3. Configuration file before and after executing configuration

- Tool options
  • Null character
- Others
  1. File as focus is on the SRC tab of project window and valid file name is selected
  2. File on which focus is in internal editor as no valid file name can be obtained in 1
  3. Null character if no valid file name can be obtained

The macros in (*2) are determined as follows:

- Customize build and tool options
  • Information on configuration of project under building, making, compiling and assembling
- Others
  1. Information on active configuration of project in which file is stored as focus is on the SRC tab of project window and valid file name is selected
  2. Information on active configuration of active project if no valid file name can be obtained in 1

*3: The macro can use only the project of the workspace project format.

*4: The content of a temporary file can be specified only with customize build.

Table 1.11-3 List of Sub parameters 1

Sub parameter	Meaning
[PATH]	Directory of file
[RELPATH]	Relative Path of file
[NAME]	Main file name of file
[EXT]	Extension of file
[SHORTFULLNAME]	Full path name of short file
[SHORTPATH]	Directory of short file
[SHORTNAME]	Main file name of short file
[FOLDER]	Name of folder in which files are stored in the SRC tab of project window (Can be specified only in %(FILE).)(*)

*: The macro can be used only the project of workspace project format.

■ Examples of Macro Expansion

If the following workspace is opened, macro expansion is performed as follows:

```
Workspace :                         C:\Wsp\Wsp.wsp
Active project :                    C:\Wsp\Sample\Sample.prj
  Active project configuration      Debug
    Object directory :              C:\Wsp\Sample\Debug\Obj\

Subproject :                        C:\Subprj\Subprj.prj
  Active project configuration      Release
    Object directory :              C:\Subprj\Release\Obj\
    Target file :                   C:\Subprj\Release\Abs\Subprj.abs
```

[Example] Macro expansion in external tools

Focus is on Subprj project file in the SRC tab of project window.

```
%a                    : C:\Subprj\Release\Abs\Subprj.abs
%A                    : SUBPRJ.abs
%D                    : C:\Subprj\Release\Abs\
%E                    : .abs
%(FILE[FOLDER])       : Source Files\Common
%(PRJFILE)            : C:\Subprj\Subprj.prj
```

Focus is not in the SRC tab of project window.

```
%a                    : C:\Wsp\Sample\Debug\Abs\Sample.abs
%A                    : Sample.abs
%D                    : C:\Wsp\Sample\Debug\Abs\
%(PRJFILE)            : C:\Wsp\Sample\Sample.prj
```

[Example] Macro expansion in customize build

Release configuration of Subprj project is built.

```
%(FILE)                 : C:\Subprj\LongNameFile.c
%(FILE[PATH])           : C:\Subprj
%(FILE[RELPATH])        : .
%(FILE[NAME])           : LongNameFile
%(FILE[EXT])            : .c
%(FILE[SHORTFULLNAME])  : C:\Subprj\LongFi = ~1.c
%(FILE[SHORTPATH])      : C:\Subprj
%(FILE[SHORTNAME])      : LongFi~1
%(PRJFILE[RELPATH])     : ..\Subprj
%(PRJPATH)              : C:\Subprj
%(OBJPATH)              : C:\Subprj\Release\Obj
%(PRJCONFIG)            : Release
%(ENV[FETOOL])          : C:\SOFTUNE
%(TEMPFILE)             : C:\Subprj\Release\Opt\_fs1056.TMP
```

[Example] Macro expansion in tool options

Release configuration of Subprj project is built.

```
%(FILE)                 :
%(PRJFILE[RELPATH])     : ..\Subprj
%(PRJPATH)              : C:\Subprj
%(OBJPATH)              : C:\Subprj\Release\Obj
%(PRJCONFIG)            : Release
%(ENV[FETOOL])          : C:\SOFTUNE
```

1.12 Setting Operating Environment

This section describes the functions for setting the SOFTUNE Workbench operating environment.

■ Operating Environment

Set the environment variables for SOFTUNE Workbench and some basic setting for the Project.

To set the operating environment, use the **[Setup]-[Setup Development Environment]** menu.

● Environment Variables

Environment variables are variables that are referred to mainly using the language tools activated from SOFTUNE Workbench. The semantics of an environment variable are displayed in the lower part of the Setup dialog. However, the semantics are not displayed for environment variables used by tools added later to SOFTUNE Workbench.

When SOFTUNE Workbench and the language tools are installed in a same directory, it is not especially necessary to change the environment variable setups.

● Basic setups for Project

The following setups are possible.

- **Open the previously worked-on Project at start up**
  When starting SOFTUNE Workbench, it automatically opens the last worked-on Project.
- **Display options while compiling/assembling**
  Compile options or assemble options can be viewed in the Output window.
- **Save dialog before closing Project**
  Before closing the Project, a dialog asking for confirmation of whether or not to save the Project to the file is displayed. If this setting is not made, SOFTUNE Workbench automatically saves the Project without any confirmation message.
- **Save dialog before compiling/assembling**
  Before compiling/assembling, a dialog asking for confirmation of whether or not to save a source file that has not been saved is displayed. If this setting is not made, the file is saved automatically before compile/assemble/make/build.
- **Termination message is highlighted at Make/Build**
  At Compile, Assemble, Make, or Build, the display color of termination messages (Abort, No Error, Warning, Error, Fatal error, or Failing During start) can be changed freely by the user.

■ Reference Section

Development Environment

Note:

Because the environment variables set here are language tools for the SOFTUNE Workbench, the environment variables set on previous versions of SOFTUNE cannot be used. In particular, add the set values of [User Include Directory] and [Library Search Directory] to [Tool Options Settings].

1.13 Debugger Types

This section describes the types of SOFTUNE Workbench debuggers.

■ Type of Debugger

SOFTUNE Workbench integrates three types of debugger: a simulator debugger, emulator debugger, and monitor debugger. Any one can be selected depending on the requirement.

■ Simulator Debugger

The simulator debugger simulates the MCU operations (executing instructions, memory space, I/O ports, interrupts, reset, etc.) with software to evaluate a program.

It is used for evaluating an uncompleted system and operation of individual units, etc.

■ Emulator Debugger

The emulator debugger is software to evaluate a program by controlling an emulator from a host through a communications line (RS-232C, LAN, USB).

Before using this debugger, the emulator must be initialized.

■ Monitor Debugger

The monitor debugger evaluates a program by putting it into an evaluation system and by communicating with a host. An RS-232C interface and an area for the debug program are required within the evaluation system.

1.14 Memory Operation Functions

This section describes the memory operation functions.

■ Functions for Memory Operations

- **Display/Modify memory data**
  Memory data can be display in the Memory window and modified.
- **Fill**
  The specified memory area can be filled with the specified data.
- **Copy**
  The data in the specified memory area can be copied to another area.
- **Compare**
  The data in the specified source area can be compared with data in the destination area.
- **Search**
  Data in the specified memory area can be searched.
  For further details of the above functions, refer to "3.11 Memory Window" in "SOFTUNE Workbench Operation Manual".
- **Display/Modify C variables**
  The names of variables in a C source file can be displayed in the Watch window and modified.
- **Setting Watch point**
  By setting a watch point at a specific address, its data can be displayed in the Watch window.
  For further details of the above functions, refer to "3.13 Watch Window" in "SOFTUNE Workbench Operation Manual".

1.15 Register Operations

This section describes the register operations.

■ Register Operations

The Register window is opened when the [View] - [Register] menu is executed. The register and flag values can be displayed in the Register window.

For further details about modifying the register value and the flag value, refer to "4.4.4 Register" in "SOFTUNE Workbench Operation Manual".

The name of the register and flag displayed in the Register window varies depending on each MCU in use. For the list of register names and flag names for the MCU in use, refer to "Appendix A Register Name List" of " SOFTUNE Workbench Operational Manual".

■ Reference Section

Register Window

1.16 Line Assembly and Disassembly

This section describes line assembly and disassembly.

■ Line Assembly

To perform line-by-line assembly (line assembly), right-click anywhere in the Disassembly window to display the short-cut menu, and select [Line Assembly]. For further details about assembly operation, refer to "4.4.3 Assembly" in "SOFTUNE Workbench Operation Manual".

■ Disassembly

To display disassembly, use the [View]-[Disassembly] menu. By default, disassembly can be viewed starting from the address pointed by the current program counter (PC). However, the address can be changed to any desired address at start-up.

Disassembly for an address outside the memory map range cannot be displayed. If this is attempted, "???" is displayed as the mnemonic.

■ Reference Section

Disassembly Window

1.17 Symbolic Debugging

The symbols defined in a source program can be used for command parameters (address). There are three types of symbols as follows:

- **Global Symbol**
- **Static Symbol within Module (Local Symbol within Module)**
- **Local Symbol within Function**

■ Types of Symbols

A symbol means the symbol defined while a program is created, and it usually has a type. Symbols become usable by loading the debug information file.

Furthermore, a type of the symbol in C language is recognized and the command is executed.

There are three types of symbols as follows:

- **Global symbol**

  A global symbol can be referred to from anywhere within a program. In C language, variables and functions defined outside a function without a static declaration are in this category. In assembler, symbols with a PUBLIC declaration are in this category.

- **Static symbol within module (Local symbol within module)**

  A static symbol within module can be referred to only within the module where the symbol is defined.

  In C language, variables and functions defined outside a function with a static declaration are in this category. In assembler, symbols without a PUBLIC declaration are in this category.

- **Local symbol within function**

  A local symbol within a function exists only in C language. A static symbol within a function and an automatic variable are in this category.

  - **Static symbol within function**

    Out of the variables defined in function, those with static declaration.

  - **Automatic variable**

    Out of the variables defined in function, those without static declaration and parameters for the function.

■ Setting Symbol Information

Symbol information in the file is set with the symbol information table by loading a debug information file. This symbol information is created for each module.

The module is constructed for each source file to be compiled in C language, in assembler for each source file to be assembled.

The debugger automatically selects the symbol information for the module to which the PC belongs to at abortion of execution (Called "the current module"). A program in C language also has information about which function the PC belongs to.

■ Line Number Information

Line number information is set with the line number information table in SOFTUNE Workbench when a debug information file is loaded. Once registered, such information can be used at anytime thereafter. Line number is defined as follows:

[Source File Name] $Line Number

1.17.1 Referring to Local Symbols

This section describes referring to local symbols and Scope.

■ Scope

When a local symbol is referred to, Scope is used to indicate the module and function to which the local symbol to be referred belongs.

SOFTUNE Workbench automatically scopes the current module and function to refer to local symbols in the current module with preference. This is called the Auto-scope function, and the module and function currently being scoped are called the Current Scope.

When specifying a local variable outside the Current Scope, the variable name should be specified by the module and function to which the variable belongs. This method of specifying a variable is called a symbol path name or a Search Scope.

■ Moving Scope

As explained earlier, there are two ways to specify the reference to a variable: by adding a Search Scope when specifying the variable name, and by moving the Current Scope to the function with the symbol to be referred to. The Current Scope can be changed by displaying the Call Stack dialog and selecting the parent function. For further details of this operation, refer to "4.6.7 Stack" in "SOFTUNE Workbench Operation Manual". Changing the Current Scope as described above does not affect the value of the PC.

By moving the current scope in this way, you can search a local symbol in parent function with precedence.

■ Specifying Symbol and Search Procedure

A symbol is specified as follows:

[[Module Name] [\Function Name] \] Symbol Name

When a symbol is specified using the module and function names, the symbol is searched. However, when only the symbol name is specified, the search is made as follows:

1. Local symbols in function in Current Scope
2. Static symbols in module in Current Scope
3. Global symbols

If a global symbol has the same name as a local symbol in the Current Scope, specify "\" or "::" at the start of global symbol. By doing so, you can explicitly show that is a global symbol.

An automatic variable can be referred to only when the variable is in memory. Otherwise, specifying an automatic variable causes an error.

1.17.2 Referring to Variable of C Language

C language variables can be specified using the same descriptions as in the source program written in C language.

■ Specifying C Language Variables

C language variables can be specified using the same descriptions as in the source program. The address of C language variables should be preceded by the ampersand symbol "&". Some examples are shown in the Table 1.17-1.

Table 1.17-1 Examples of Specifying Variables

Example of Variables		Example of Specifying Variables	Semantics
Regular Variable	int data;	data	Value of data
Pointer	char *p;	*p	Value pointed to by p
Array	char a[5];	a[1]	Value of second element of a

Structure	struct stag {
	  char c;
	  int i;
	};
	struct stag st;
	struct stag *stp;
		st.c
		stp- >c
			Value of member c of st
			Value of member c of the structure to which stp points

Union	union utag {
	  char c;
	  int i;
	} uni;
		uni.i	Value of member i of uni

Address of variable	int data;	&data	Address of data
Reference type	int i; int &ri = i;	ri	Same as i

■ Notes on C Language Symbols

The C compiler outputs symbol information with "_" prefixed to global symbols. For example, the symbol main outputs symbol information _main. However, SOFTUNE Workbench permits access using the symbol name described in the source to make the debug of program described by C language easier.

Consequently, a symbol name described in C language and a symbol name described in assembler, which should both be unique, may be identical.

In such a case, the symbol name in the Current Scope normally is preferred. To refer to a symbol name outside the Current Scope, specify the symbol with the module name.

If there are duplicated symbols outside the Current Scope, the symbol name searched first becomes valid. To refer to another one, specify the symbol with the module name.

CHAPTER 2

DEPENDENCE FUNCTIONS

This chapter describes the functions dependent on each Debugger.

2.1 Simulator Debugger

This section describes the functions of the simulator debugger for the F^{2}MC-16 Family.

■ Simulator Debugger

The simulator debugger simulates the MCU operations (executing instructions, memory space, I/O ports, interrupts, reset, etc.) with software to evaluate a program.

It is used to evaluate an uncompleted system, the operation of single units, etc.

There are 2 types of simulator debuggers.

- Normal simulator debugger (normal)
- High-speed simulator debugger (fast)

This high-speed simulator debugger provides substantial reductions in simulation time due to a dramatic review of normal simulator debugger's processing methods.

The high-speed simulator debugger can be instruction processing performance for 10MIPS when it is operated by PC equipped with Pentium4 2.0GHz.

External I/F for simulator are equipped to high-speed simulator debugger to create peripheral simulation modules.

Please refer to "Appendix I External I/F DLL for Simulator" in "SOFTUNE Workbench Operation Manual".

■ Operating Condition of High-speed Simulator Debugger

The high-speed simulator debugger requires much more RAM space on the host PC than that of normal simulator debugger.

The required RAM size depends largely on your program size.

For the required available RAM space, see the table below:

Basic use	Fs907s.exe (This product)	20MB
CODE size of target program	per 64 KB	6MB
DATA size of target program	per 64 KB	1.5MB

Insufficient RAM space will lead to an extreme decrease in simulation speed.

Target program size

CODE XX(KB)

DATA YY(KB)

Required RAM space (MB) = $20 + (XX / 64) \times 6 + (YY / 64) \times 1.5$

However, RAM space larger than the above may be needed depending on program allocation. Consecutive areas should be reserved as much as possible.

Example: Program with 1 MB of CODE and DATA sizes

Required RAM space (MB) = $20 + (1024 / 64) \times 6 + (1024 / 64) \times 1.5 = 140$MB

■ Simulation Range

The simulator debugger simulates the MCU operations (instruction operations, memory space, I/O ports, interrupts, reset, power-save consumption mode, etc.) Peripheral I/Os, such as a timer, DMAC and serial I/O, other than the CPU core of the actual chip are not supported as peripheral resources. I/O space to which peripheral I/Os are connected is treated as memory space. There is a method for simulating interrupts like timer interrupts, and data input to memory like I/O ports. For details, see the sections concerning I/O port simulation and interrupt simulation.

- Instruction simulation
- Memory simulation
- I/O port simulation (Input port)
- I/O port simulation (Output port)
- Interrupt simulation
- Reset simulation
- Power-save consumption mode simulation

2.1.1 Setting Operating Environment

This section explains the operating environment setup.

■ Setting Operating Environment

For the simulator debugger for F^2MC-16FX, it is necessary to set the following operating environment. Its predefined default settings are enabled at startup. Therefore, setup is not required when using the default settings. Adjusted settings can be used as new default settings from the next time.

- Boot ROM file automatic execution

2.1.1.1 Boot ROM File Automatic Execution

The simulator debugger for F^{2}MC-16FX automatically loads and executes the Boot ROM file at the start of debugging.

■ Boot ROM File Automatic Execution

When the simulator debugger for F^{2}MC-16FX is specified, the Boot ROM file is automatically loaded and then executed at the start of debugging. The Boot ROM file is stored in Lib\907\BootROM under the directory where Workbench is installed.

The directory containing the Boot ROM file can be displayed using the [Project] - [Setup Project] menu, and can be modified in the setup project dialog. In addition, it is also possible to automatically execute the Boot ROM file during the debugger startup or reset of MCU. For details, see the "SOFTUNE Workbench Operation Manual".

Notes:

- When MCU reset is performed in the simulator debugger, the PC value varies, as shown below, depending on whether it is F^{2}MC-16FX or not:

  F^{2}MC-16FX: Starting address of the Boot ROM file

  Other than F^{2}MC-16FX: Entry point in the target file (reset vector)
- As the simulator debugger does not support fixed boot vectors, it always jumps to the reset vector after the execution of the Boot ROM file. For the operation after the execution of the Boot ROM file, see the LSI Specification Manual.

2.1.2 Instruction Simulation

This section describes the instruction simulation executed by SOFTUNE Workbench.

■ Instruction Simulation

This simulates the operations of all instructions supported by the F^2MC-16/16L/16LX/16H/16F. It also simulates the changes in memory and register values due to such instructions.

2.1.3 Memory Simulation

This section describes the memory simulation executed by SOFTUNE Workbench.

■ Memory Simulation

The simulator debugger must first secure memory space to simulate instructions because it simulates the memory space secured in the host PC memory.

The following operation is required.

- To secure the memory area, either use the [Setup] - [Memory Map] menu, or the SET MAP command in the Command window.
- Load the file output by the Linkage Editor (Load Module File) using either the [Debug] - [Load target file] menu, or the LOAD/OBJECT command in the Command window.

■ Simulation Memory Space

Memory space access attributes can be specified byte-by-byte using the [Setup] - [Memory Map] menu. The access attribute of unspecified memory space is Undefined using the [Setup] - [Memory Map] menu.

■ Memory Area Access Attributes

Access attributes for memory area can be specified as shown in Table 2.1-1. A guarded access break occurs if access is attempted against such access attribute while executing a program. When access is made by a program command, such access is allowed regardless of the attribute, CODE, READ or WRITE. However, access to memory in an undefined area causes an error.

Table 2.1-1 Types of Access Attributes

Attribute	Semantics
CODE	Instruction operation enabled
READ	Data read enabled
WRITE	Data write enabled
undefined	Attribute undefined (access prohibited)

2.1.4 I/O Port Simulation

This section describes I/O port simulation executed by SOFTUNE Workbench.

■ I/O Port Simulation (Input Port)

There are two types of simulations in I/O port simulation: input port simulation, and output port simulation. Input port simulation has the following types:

- Whenever a program reads the specified port, data is input from the pre-defined data input source.
- Whenever the instruction execution cycle count exceeds the specified cycle count, data is input to the port.

To set an input port, use the [Setup] - [Debug Environment] - [I/O Port] menu, or the SET INPORT command in the Command window.

Up to 4096 port addresses can be specified for the input port. The data input source can be a file or a terminal. After reading the last data from the file, the data is read again from the beginning of the file. If a terminal is specified, the input terminal is displayed at read access to the set port.

A text file created by an ordinary text editor, or a binary file containing direct code can be used as the data input file. When using a text file, input the input data inside commas (,). When using a binary file, select the binary radio button in the input port dialog.

■ I/O Port Simulation (Output Port)

At output port simulation, whenever a program writes data to the specified port, writing is executed to the data output destination.

To set an output port, either use the [Setup] - [Debug Environment] - [I/O Port] menu, or the SET OUTPORT command in the Command window.

Up to 4096 port addresses can be set as output ports. Select either a file or terminal (Output Terminal window) as the data output destination.

A destination file must be either a text file that can be referred to by regular editors, or a binary file. To output a binary file, select the Binary radio button in the Output Port dialog.

Note:

The following method is not supported by high-speed simulator debugger.

- Whenever the instruction execution cycle count exceeds the specified cycle count, data is input to the port.

Furthermore the setting of memory map is necessary to set I/O port. When deleting memory map, I/O port is also deleted.

2.1.5 Interrupt Simulation

This section describes the interrupt simulation executed by SOFTUNE Workbench.

■ Interrupt Simulation

Simulate the operation of the MCU (including intelligent I/O service*) in response to an interrupt request. Note that intelligent I/O service does not support any end request from the resource.

Provisions for the causes of interrupts and interrupt control registers are made by referencing data in the install file read at simulator start up.

*: Automatic data transfer function between I/O and memory is called an intelligent I/O service. This function allows exchange of data between memory and I/O, which was done previously by the interrupt handling program, using DMA (Direct Memory Access). (For details, refer to the user manual for each model.)

The methods of generating interrupts are as follows:

- Execute instructions for the specified number of cycles while the program is running (during execution of executable commands) to generate interrupts corresponding to the specified interrupt numbers and cancel the interrupt generating conditions.
- Continue to generate interrupts each time the number of instruction execution cycles exceeds the specified number of cycles.

The method of generating interrupts is set by the [Setup]-[Debug environment]-[Interrupt] menu. If interrupts are masked by the interrupt enable flag when the interrupt generating conditions are established, the interrupts are generated after they are unmasked.

MCU operation in response to an interrupt request is also supported for the following exception handling:

- Execution of undefined instructions
- Address error in program access
  (Program access to internal RAM area and internal I/O area)
- Stack area error (only for F^2MC-16F)

Note:

When an external interrupt is generated while under an interrupt mask at high-speed simulator debugger, that interrupt factor is eliminated.

2.1.6 Reset Simulation

This section describes the reset simulation executed by SOFTUNE Workbench.

■ Reset Simulation

The simulator debugger simulates the operation when a reset signal is input to the MCU using the [Debug]-[Reset MCU] menu and initializes the registers. The function for performing reset processing by operation of MCU instructions (writing to RST bit in standby control register) is also supported. In this case, the reset message (Reset) is displayed on the status bar.

2.1.7 Low-Power Consumption Mode Simulation

This section describes the low-power consumption SOFTUNE Workbench mode simulation executed by SOFTUNE Workbench.

■ Low-Power Consumption Mode Simulation

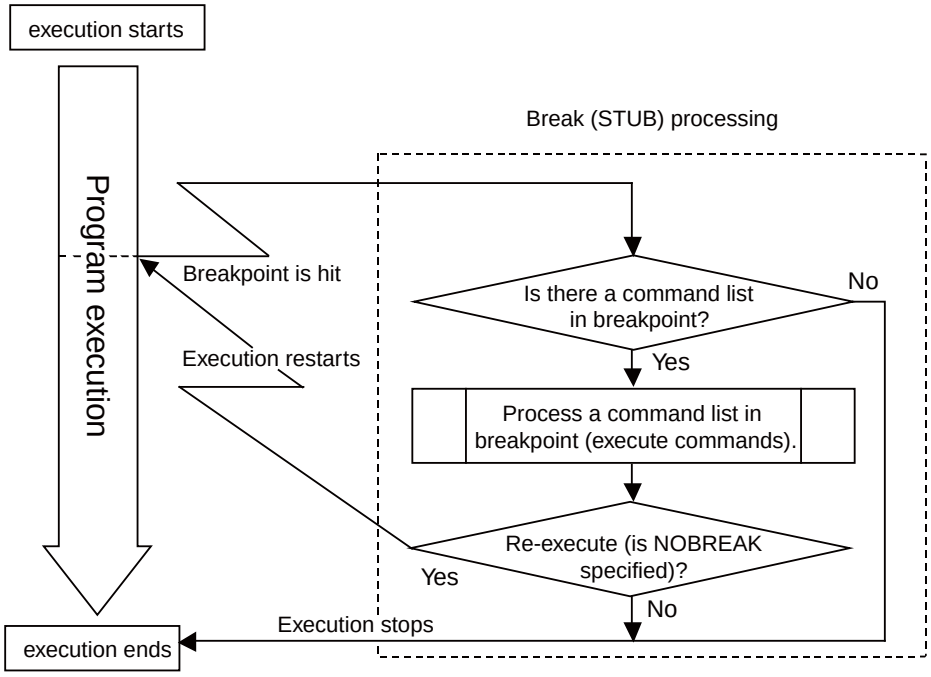
The MCU enters the low-power consumption mode in accordance with the MCU instruction operation (Write to SLEEP bit or STOP bit of standby control register). Once in the sleep mode or stop mode, a message ("sleep" for sleep mode, "stop" for stop mode) is displayed on the Status Bar. The loop keeps running until either an interrupt request is generated, or the [Debug] - [Abort] menu is executed. Each cycle of the loop increments the count by 1. During this period, I/O port processing can be operated. Writing to the standby control register using a command is not prohibited.

2.1.8 STUB Function

This section describes the STUB function which executes commands automatically when the breakpoint hit occurs.

■ STUB Function

The STUB function is supported so that a series of commands in the command list can automatically be executed when a specified breakpoint is hit. The use of this function enables spot processing, such as simple I/O simulation, external interrupt generation, and memory reprogramming, without changing the main program. This function is effective only when the simulator debugger is used.



■ Setting Method

The STUB function can be set by the following commands.

- Dialog
  1. Breakpoint Set Dialog - [Code] tab
  2. Breakpoint Set Dialog - [Data] tab
- Command
  1. SET BREAK
  2. SET DATABREAK

2.1.9 Break

In the simulator debugger, five types of break functions can be used. When the program execution is aborted by each break function, the address and the break factor to do the break are displayed.

■ Break Functions

In this simulator debugger, the following five types of break functions are supported.

- Code break
- Data break
- Trace-buffer-full break
- Guarded break
- Forced break

2.1.9.1 Code Break

It is a function that the simulator debugger aborts the program execution when the code access specified while executing the program is done.

■ Flow of Code Break

When the program reaches the breakpoint (Immediately before an instruction memory positional is executed), the simulator debugger does the following processing.

1) The execution of the program is aborted (Before executing the instruction).
2) When the attainment frequency is checked, and it doesn't reach the attainment frequency of the specified breakpoint, the program execution is restarted. It moves to 3) when it reaches the attainment frequency.
3) The memory position in which execution was aborted is displayed in the status bar.

The breakpoint can be set up to 65535 points or less.

When a break occurs due to a code break, the following message is displayed on the Status Bar.

Break at Address by breakpoint

■ Setting Method

The code break is controlled by the following method.

- Command
  - SET BREAK
    Refer to "3.1 SET BREAK (type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Breakpoint Set Dialog [Code] tab
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".
- Window
  - Source window/Disassembly window

■ Notes on Code Break

There are several points to note in using code break. First, some points affecting code break are explained.

● Invalid Breakpoints

- No break occurs when a breakpoint is set at the instruction immediately after the following instructions.

  F^2MC-16/16L/16LX/16H: • PCB • DTB • NCC • ADB • SPB • CNR
  • MOV ILM,#imm8 • AND CCR,#imm8
  • OR CCR,#imm8 • POPW PS

  F^2MC-16F: • PCB • DTB • NCC • ADB • SPB • CNR
- No break occurs when breakpoint set at address other than starting address of instruction.

Here are some additional points about the effects on other commands.

● Dangerous BreakPoints

- Never set a breakpoint at an address other than the instruction starting address.
- If a breakpoint is the last 1 byte of an instruction longer than 2 bytes length, and if such an address is even, the following abnormal operation will result:
  - If instruction executed by STEP command, instruction execution not aborted.
  - If breakpoint specified with GO command, set at instruction immediately after such instruction, the breakpoint does not break.

Note:

[High-speed version simulator debugger]

- When the break function is used, it is necessary to set the memory map beforehand. When the memory map is deleted, the setting of the breakpoint is deleted.
- When the breakpoint with pass count is set to the reset vector in 16FX, hit count is cleared after the Boot ROM file is executed. For details of the execution of the Boot ROM file, refer to "■ Setting Options in [Boot ROM] (Only MB2198)" of section "4.5.5.9 Setting Debug Options" in "SOFTUNE Workbench Operation Manual".

2.1.9.2 Data Break

It is a function that the simulator debugger aborts the program execution when the data access (read and write) specified while executing the program is done.

■ Flow of Data Break

The simulator debugger does the following processing when the program writes in the breakpoint or it reads it.

1) After the execution of the instruction is completed, the execution of the program is aborted.
2) It moves to 3) when the program execution is restarted when the access frequency is checked, and it doesn't reach the access frequency of the specified data break, and it reaches the access frequency.
3) When it reaches the access frequency and the program execution is aborted, the memory position of the instruction in which it is writing (Or, read it) is displayed to the memory position of the data breakpoint and the memory position in the status bar.
4) Next, the executed memory position is displayed.

The breakpoint can be set up to 65535 points or less.

When a break occurs due to a data break, the following message is displayed on the Status Bar.

Break at Address by databreak at Access address

■ Setting Method

The data break is controlled by the following method.

- Command
  - SET DATABREAK
    Refer to "3.10 SET DATABREAK (type 2)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Breakpoint Set Dialog [Data] tab
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".

Note:

[High-speed version simulator debugger]

- When the break function is used, it is necessary to set the memory map beforehand. When the memory map is deleted, the setting of the breakpoint is deleted.
- When the breakpoint with pass count is set to the reset vector in 16FX, hit count is cleared after the Boot ROM file is executed. For details of the execution of the Boot ROM file, refer to "■ Setting Options in [Boot ROM] (Only MB2198)" of section "4.5.5.9 Setting Debug Options" in "SOFTUNE Workbench Operation Manual".

2.1.9.3 Trace-Buffer-Full Break

It is a function to abort the program execution when the trace buffer becomes full.

■ Trace-Buffer-Full Break

It is a function to abort the program execution when the trace buffer becomes full.

When a break occurs due to a trace-buffer-full break, the following message is displayed on the Status Bar.

Break at Address by trace buffer full

■ Setting Method

The trace-buffer-full break is controlled by the following method.

- Command
  - SET TRACE/BREAK
    Refer to "4.29 SET TRACE(type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Trace Set Dialog
    Refer to "4.4.8 Trace" in "SOFTUNE Workbench Operation Manual".

2.1.9.4 Guarded Access Break

It is a function to abort the program execution when the violation to the access attribute, doing the access, and guarded (An undefined area cannot be accessed) area are accessed.

■ Guarded Access Break

It is a function to abort the program execution when the violation to the access attribute, doing the access, and guarded (An undefined area cannot be accessed) area are accessed.

Guarded access break functions as follows.

- Code guarded
  When the instruction execution to the area without the code attribute
- Read guarded
  When read the area without the read attribute
- Write guarded
  When writing it in the area without the write attribute

When a break occurs due to a guarded break, the following message is displayed on the Status Bar.

Break at Address by guarded access {code/read/write} at Access address

2.1.9.5 Forced Break

It is a function to abort the execution of the program compulsorily.

■ Forced Break

It is a function to abort the execution of the program compulsorily.

When a break occurs due to a forced break, the following message is displayed on the Status Bar.

Break at Address by command abort request

2.1.10 Measuring Execution Cycle Count

This function measures the program execution cycle count.

■ Measurement Items

Measures program execution cycle count and step counts.

● Execution Cycle Count

This is calculated based on the basic cycle count of each instruction described in the Programming Manual.

A compensation value (a, b), which is described in the list of an instruction in Programming Manual, is calculated as 1.

The maximum measurable value varies, as shown below, whether the normal or the high-speed simulator debugger is used.

Normal debugger: Max. (2 to the power of 32 - 1) = 4,294,967,295 cycles

High-speed debugger: Max. (2 to the power of 64 - 1) = 18,446,744,073,709,551,615 cycles

● Execution Step Count

Measures program execution step counts.

For both the normal simulator debugger and the high-speed simulator debugger, the maximum measurable count is "2 to the power of 32 - 1", in other words, up to 4,294,967,295 steps.

The measurement is performed whenever a program is executed, and the measurement result displays the following two values:

- Step counts spent on the previous program execution
- Total step counts spent on the program execution since the previous clearing

■ Displaying Measurement Results

Either of the following methods can be used to display the measurement results.

● Display by dialog

The results appear in the time measurement dialog, which can be displayed by selecting [Debug] – [Time Measurement] menu.

For details, refer to Section "4.6.8 Time Measurement" in "SOFTUNE Workbench Operation Manual".

● Display by command

Enter the SHOW TIMER command in the command window.

For details, refer to Section "4.27 SHOW TIMER" in "SOFTUNE Workbench Command Reference Manual".

■ Clearing Measurement Results

Either of the following methods can be used to clear the measurement results.

- Operation by dialog

  Click the [Clear] button in the time measurement dialog, which can be displayed by selecting [Debug] – [Time Measurement] menu.

  For details, refer to Section "4.6.8 Time Measurement" in "SOFTUNE Workbench Operation Manual".

- Clearing by command

  Enter the CLEAR TIMER command in the command window.

  For details, refer to Section "4.28 CLEAR TIMER" in "SOFTUNE Workbench Command Reference Manual".

Note:

Because no simulation was done on pipeline process or cache operation inside the chip, it may differ from an actual chip for normal simulator debugger and/or high-speed simulator debugger.

2.1.11 Trace

The address and status information can be sampled during program execution to record it in a trace buffer. This function is called a trace.

■ Trace

The address and status information can be sampled during program execution to record it in a trace buffer. This function is called a trace. Data of the trace buffer can be used to make a detailed analysis of a program execution history.

The trace buffer is in the form of a ring. When it becomes full, it records the next data by automatically overwriting the buffered data at the beginning.

■ Trace Data

The simulator debugger can sample 1000 frames of trace data for the address of the executed instruction.

■ Abortion of Trace Measurement

While the trace function is enabled, data is always sampled and recorded in the trace buffer during execution of a user program.

The program execution aborts due to a break factor such as a breakpoint, terminating the trace.

Furthermore, when the trace buffer becomes full, a program break can be invoked. This break is called a trace buffer full break.

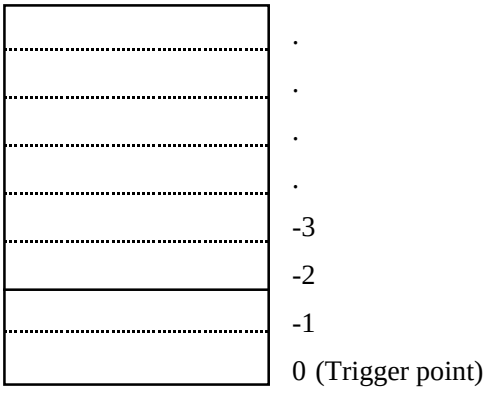
■ Frame Number

A number is assigned to each frame of sampled trace data. This number is called a frame number.

The frame number is used to specify the display start position of the trace buffer.

The number 0 is assigned to the last-sampled trace data. Negative values are assigned to trace data that have been sampled before the arrival at the triggering position.

Figure 2.1-1 Frame Numbering at Tracing



2.1.11.1 Setting Trace

You must set the following two items to perform a trace. After that, trace data will be sampled with the execution of the program.

■ Setting Trace

1. Enable the trace function. This program will startup and will be enabled.
   - Dialog

     This is done by [Setup] - [Trace] in the trace window shortcut menu.
   - Command

     Enter the ENABLE TRACE command.
2. Set the trace buffer full break. When the trace buffer is full, you can make a break. When starting up this program, it is setup for no breaks.
   - Dialog

     This is done using the trace window shortcut menu [Setup] - [Trace].
   - Command

     Enter the SET TRACE/BREAK command.

2.1.11.2 Displaying Trace Data

Data recorded in the trace buffer can be displayed.

■ Displaying Trace Data

The trace window or command window displays how much trace data is stored in the trace buffer.

- Trace window
  Select [Refresh] in the trace window shortcut menu.
- Command window
  Enter the SHOW TRACE command.

■ Display Format of Trace Data

There are two display formats of the trace data.

- Instruction: The instruction operation is displayed in disassembly units.
- Source: This mode only displays source lines.

■ Clearing Trace Data

Either of the following methods can be used to clear data in the trace buffer.

- Window
  Select [Clear] in the trace window shortcut menu.
- Command
  Enter the CLEAR TRACE command.

2.1.11.3 Searching Trace Data

The trace buffer can be searched to locate target data.

■ Searching Trace Data

The trace buffer has 1000 frames, so the target data may not be found immediately. Therefore the trace data can be searched from data in the trace buffer by specifying an address.

■ How to Search Trace Data

Either of the following methods can be used to search the trace data.

- Window
  Select [Find] in the trace window shortcut menu.
- Command
  Enter the SEARCH TRACE command.

2.1.11.4 Saving Trace Data

This section explains how to save trace data.

■ Saving Trace Data

Trace data can be saved in a specified file.

The following two methods are available to save trace data: using GUI (window or dialog) and using only the command. The same result is obtained from both methods.

● Using GUI for Saving Trace Data

1. Display the trace window.
   - Select [View] - [Trace] menu.
2. Specify the name of the file in which to save trace data.
   - Right-click on the trace window, and select [Save] from the shortcut menu. The [Save as] dialog appears.
     Specify the file name and where to save trace data. For details, refer to Section "4.4.8 Trace" in "SOFTUNE Workbench Operation Manual".

● Using Command for Saving Trace Data

1. Save trace data.
   - Execute the SHOW TRACE/FILE command.
     For details, refer to Section "4.33 SHOW TRACE (type 3)" in "SOFTUNE Workbench Command Reference Manual".
     When additionally saving trace data in an existing file, execute the SHOW TRACE/FILE/APPEND command.

2.1.12 Measuring Coverage

In the high-speed version simulator debugger, the C0 coverage measurement function is provided. Use this function to find what percentage of an entire program has been executed.

■ Coverage Measurement Function

When testing a program, the program is executed with various test data input and the results are checked for correctness. When the test is finished, every part of the entire program should have been executed. If any part has not been executed, there is a possibility that the test is insufficient.

It can know what percentage of the entire program executed when the coverage function for the high-speed version simulator debugger to have is used.

In addition, details such as which addresses were not accessed can be checked.

In this debugger, the range to measure coverage can be set.

Please set the time base range only to the code area when you do the C0 coverage.

Moreover, the access of the variable can be examined as the variable not used is searched out by setting the time base range to the data area.

■ Coverage Measurement Procedures

The procedure for coverage measurement is as follows:

- Set range for coverage measurement: SET COVERAGE
- Measuring coverage: GO, STEP, CALL
- Displaying measurement result: SHOW COVERAGE

■ Coverage Measurement Operation

The following operation can be made in coverage measurement:

- Load/Save of coverage data: LOAD/COVERAGE. SAVE/COVERAGE
- Clearing coverage data: CLEAR COVERAGE
- Canceling coverage measurement range: CANCEL COVERAGE

2.1.12.1 Coverage Measurement Procedures

The procedure for coverage measurement is as follows:

- **Set range for coverage measurement:SET COVERAGE**
- **Measure coverage:GO, STEP, CALL**
- **Display measurement result:SHOW COVERAGE**

■ Setting Range for Coverage Measurement

Use the SET COVERAGE command to set the measurement range. Up to 32 ranges can be specified.

By specifying /AUTOMATIC for the command qualifier, the code area for the loaded module is set automatically. However, the library code area is not set when the C compiler library is linked.

[Example]

```
>SET COVERAGE FF0000..FFFFFF
```

■ Measuring Coverage

When preparing for coverage measurement, execute the program.

Measurement starts when the program is executed by using the GO, STEP, or CALL command.

■ Displaying Coverage Measurement Result

To display the coverage measurement result, use the SHOW COVERAGE command. The following can be displayed:

- Display coverage rate of total measurement area
- Displaying coverage rate of load module
- Summary of 16 addresses as one block
- Details indicating access status of each address
- Displaying coverage measurement result per source line
- Displaying coverage measurement result per machine instruction

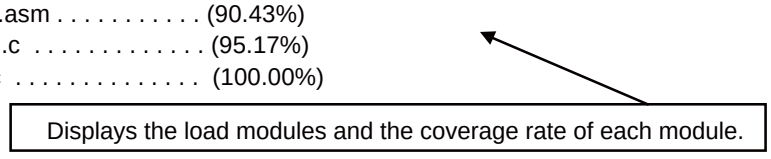
● Displaying coverage rate of total measurement area (specify /TOTAL for the command qualifier)

```
>SHOW COVERAGE/TOTAL
```

total coverage : 82.3%

● Displaying coverage rate of load module (specify /MODULE for the command qualifier)

```
>SHOW COVERAGE/MODULE
sample.abs  . . . . . . . . . . . . . (84.03%)
 +- startup.asm . . . . . . . . . . . (90.43%)
 +- sample.c  . . . . . . . . . . . . (95.17%)
 +- samp.c  . . . . . . . . . . . . .  (100.00%)
```



● Summary (Specify /GENERAL for command qualifier)

```
>SHOW COVERAGE/GENERAL
  (HEX)0X0            +1X0            +2X0
       +---------------+---------------+------         ------
address 0123456789ABCDEF0123456789ABCDEF0123456    ... ABCDEF   C0(%)
FF0000  **3*F*......                                            32.0
```

Display the access status of every 16 addresses
- . : No access
- 1 to F : Display the number accessed in 16 addresses by the hexadecimal number.
- * : Access all of the 16 addresses.

● Details (Specify /DETAIL for command qualifier)

Display one line of a coverage rate

```
>SHOW COVERAGE/DETAIL FF0000

address +0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +A +B +C +D +E +F C0(%)
FF0000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  - 100.0
FF0010   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  - 100.0
FF0020   .  .  .  .  -  -  -  .  .  .  .  .  .  .  .  .  18.6
FF0030   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  - 100.0
FF0040   -  .  -  -  -  -  -  -  -  -  -  -  -  -  -  -  93.7
FF0050   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  - 100.0
FF0060   .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .   0.0
FF0070   .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .   0.0
FF0080   .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .   0.0
```

Display the access status of every 1 address
- . : No access
- - : Access

- Displays per source line (specify /SOURCE for the command qualifier)

```
>SHOW COVERAGE/SOURCE main
 *     70: {
       71:       int     i;
       72:       struct table *value[16];
       73:
 *     74:       for (i=0; i<16; i++)
 *     75:             value[i] = &target[i];
       76:
 *     77:       sort_val(value, 16L);
 .     78: }
```

Displays execution status of each source line.

. :	No executing
* :	Executing
Blank :	Line which the code had not been generated or is outside the scope of the coverage measurement

- Displays per machine instruction (specify /INSTRUCTION for the command qualifier)

```
>SHOW COVERAGE/INSTRUCTION F9028F
sample.c$70 {
 *  F9028F                \main:
 *  F9028F 0822                LINK    #22
 *  F90291 4F01                PUSHW   RW0
sample.c$74       for (i=0; i<16; i++)
 .  F90293 D0                  MOVN    A,#0
 .  F90294 CBFE                MOVW    @RW3-02,A
 .  F90296 BBFE                MOVW    A,@RW3-02
 .  F90298 3B1000              CMPW    A,#0010
 .  F9029B FB18                BGE     F902B5
sample.c$75           value[i] = &target[i];
 .  F9029D BBFE                MOVW    A,@RW3-02
 .  F9029F 0C                  LSLW    A
 .  F902A0 98                  MOVW    RW0,A
 .  F902A1 71F3DE              MOVEA   A,@RW3-22
 .  F902A4 7700                ADDW    RW0,A
 .  F902A6 4214                MOV     A,#14
 .  F902A8 7833FE              MULUW   A,@RW3-02
 .  F902AB 38A001              ADDW    A,#01A0
```

Displays execution status of each machine command line.

. :	No executing
* :	Executing
Blank :	Instruction outside the scope of the coverage measurement

2.1.13 Checking Debugger Information

This section explains how to check information about the simulator debugger.

■ Debugger Information

This simulator debugger enables you to check the following information at startup.

- SOFTUNE Workbench file information

If any errors have been discovered during SOFTUNE Workbench operations, check this information and contact our sales department or support department.

■ How to Check

Use one of the following methods to check debugger information.

- Command
  - SHOW SYSTEM
    Refer to Section "1.19 SHOW SYSTEM" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Version information dialog
    Select [Help] - [Version Information] menu.
    For details, refer to Section "4.9.3 Version Information" in "SOFTUNE Workbench Operation Manual".

■ Displayed Contents

```
F2MC-16 Family SOFTUNE Workbench VxxLxx
ALL RIGHTS RESERVED,
  COPYRIGHT(C) FUJITSU SEMICONDUCTOR LIMITED 1997
LICENCED MATERIAL -
  PROGRAM PROPERTY OF FUJITSU SEMICONDUCTOR LIMITED
=========================================================
Cpu information file path: CPU information file path
Cpu information file version: CPU information file version
=========================================================
Add in DLLs
---------------------------------------------------------
 SiCmn
 Product name: SOFTUNE Workbench
 File Path: SiC907.dll path
 Version: SiC907.dll version
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 SiiEd
 File Path: SiiEd3.ocx path
 Version: SiiEd3.ocx version
---------------------------------------------------------
 SiM907
 Product name: SOFTUNE Workbench
 File Path: SiM907.dll path
 Version: SiM907.dll version
```

```
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Language Tools
 - F2MC-16 Family SOFTUNE C Compiler version
   File Path: fcc907s.exe path
 - F2MC-16 Family SOFTUNE Assembler version
   File Path: fasm907s.exe path
 - F2MC-16 Family SOFTUNE Linker version
   File Path: flnk907s.exe path
 - F2MC-16 Family SOFTUNE Librarian version
   File Path: flib907s.exe path
 - SOFTUNE FJ-OMF to S-FORMAT Converter version
   File Path: f2ms.exe path
 - SOFTUNE FJ-OMF to INTEL-HEX Converter version
   File Path: f2is.exe path
 - SOFTUNE FJ-OMF to INTEL-EXT-HEX Converter version
   File Path: f2es.exe path
 - SOFTUNE FJ-OMF to HEX Converter version
   File Path: f2hs.exe path
-------------------------------------------------------
 SiOsM
 Product name: Softune Workbench
 File Path: SiOsM907.dll path
 Version: SiOsM907.dll version
-------------------------------------------------------
 F2MC-16 Series Debugger DLL
 Product name: SOFTUNE Workbench
 File Path: SiD907.dll path
 Version: SiD907.dll version
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Debugger type     : Current debbuger type
MCU type          : Currently selected target MCU
VCpu dll name     : Path and name of the currently used VCpu dll
VCpu dll version  : Version of the currently used virtual debugger DLL
REALOS version    : REALOS version
-------------------------------------------------------
 SiIODef
 Product name: Softune Workbench
 File Path: SiIODef.dll path
 Version: SiIODef.dll version
=======================================================
Current path: Path of the currently used project
Language: Currently used language
Help file path: Help file path
```

2.2 Emulator Debugger (MB2141)

This section explains the functions of the emulator debuggers for the MB2141.

■ Emulator Debugger

When choosing the emulator debugger from the setup wizard, select one of the following emulators. The following description explains the case when MB2141 has been selected.

MB2141
MB2147-01
MB2147-05
MB2198

The emulator debugger for the MB2141 is software that controls an emulator from a host computer via a communications line (RS-232C or LAN) to evaluate programs.

The following series can be debugged:

When MB2141-506 pod used

F^2MC-16/16H
F^2MC-16F
F^2MC-16L
F^2MC-16LX

When MB2141-507 pod used

F^2MC-16F
F^2MC-16L
F^2MC-16LX

Before using the emulator, the emulator must be initialized.

For further details, refer to "Appendix B Download Monitor Program", and "Appendix C Setting up LAN Interface" in "SOFTUNE Workbench Operation Manual".

2.2.1 Setting Operating Environment

This section explains the operating environment setup.

■ Setting Operating Environment

For the emulator debugger for the MB2141, it is necessary to set the following operating environment. Predefined default settings for all these setup items are enabled at startup. Therefore, setup is not required when using the default settings. Adjusted settings can be used as new default settings from the next time.

- MCU operation mode
- Debug area
- Memory mapping
- Timer minimum measurement unit

2.2.1.1 MCU Operation Mode

There are two MCU operation modes as follows:

- **Debugging Mode**
- **Native Mode**

■ Setting MCU Operation Mode

Set the MCU operation mode.

There are two operation modes: the debugging mode, and the native mode. Choose either one using the SET RUNMODE command.

At emulator start-up, the MCU is in the debugging mode.

When the MCU operation mode is changed, all the following are initialized:

- Data breakpoints
- Event condition settings
- Sequencer settings
- Trace measurement settings and trace buffer
- Performance measurement settings and measured result

● Debugging Mode

All the operations of evaluation chips can be analyzed, but their operating speed is slower than that of mass-produced chips.

● Native Mode

Evaluation chips have the same timing as mass-produced chips to control the operating speed. Note that the restrictions the shown in Table 2.2-1 are imposed on the debug functions.

Table 2.2-1 Restrictions on Debug Functions in Native Mode

Applicable series	Restrictions on debug functions
F^2MC-16/16H	- Memory mapping setting is disabled and each area is accessed to the MCU specifications. - Traces cannot be disassembled.
Common to all series	- When a data read access occurs on the MCU internal bus, the internal bus access information is not sampled and stored in the trace buffer. - Even when a data break or event (data access condition) is set for data on the MCU internal bus, it may not become a break factor or sequencer-triggering factor. - The coverage function may fail to detect an access to data on the MCU internal bus.

■ MCU Operation Speed

To support a broader range of MCU operation speeds, the emulator adjusts control of the MCU according to the MCU operation speed.

Normally, set the low-speed operation mode. If the F^2MC-16H/16F series is operated at high speed and malfunctions occur, change the setting to the high-speed operation mode.

Also, to start at low speed and then change to high speed because of the gear setting, etc., use the SET RUNMODE command to change the setting.

2.2.1.2 Debug Area

Set the intensive debugging area out of the whole memory space. The area functions are enhanced.

■ Setting Debug Area

There are two debug areas: DEBUG1, and DEBUG2. A continuous 512KB area (8 banks) is set for each area.

Set the debug area using the SET DEBUG command.

Setting the debug area enhances the breakpoints/data breakpoints and the coverage measurement function.

- Enhancement of Breakpoints

Up to six breakpoints (not including temporary breakpoints set using GO command) can be set when the debug area has not been set yet.

When setting the debug area as the CODE attribute, up to 65535 breakpoints can be set if they are within the area. At this time, up to six breakpoints can be set for an area other than the debug area, but the total count of breakpoints must not exceed 65535.

- Enhancement of Data Breakpoints

Up to six data breakpoints can be set when the debug area has not been set yet.

When setting the debug area of the data attribute (READ, WRITE), up to 65535 data breakpoints can be set if they are within the area and have the same attribute. At this time, up to six data breakpoints can be set for an area other than the area or for a different attribute, but the total number of data breakpoints must not exceed 65535.

- Enhancement of Coverage Measurement Function

Setting the debug area enables the coverage measurement function. In coverage measurement, the measurement range can be specified only within the area specified as the debug area.

The attributes for the debug area are "Don't care" as long as it is being used for coverage measurement. The coverage measurement attribute can be set, regardless of the debug area attributes.

2.2.1.3 Memory Area Types

A unit in which memory is allocated is called an area. There are seven different area types.

■ Memory Area Types

A unit to allocate memory is allocated is called an area. There are seven different area types as follows:

- User Memory Area

Memory space in the user system is called the user memory area and this memory is called the user memory. Up to eight user memory areas can be set with no limit on the size of each area.

Access attributes can be set for each area; for example, CODE, READ, etc., can be set for ROM area, and READ, WRITE, etc. can be set for RAM area. If the MCU attempts access in violation of these attributes, the MCU operation is suspended and an error is displayed (guarded access break).

To set the user memory area, use the SET MAP command. The F^2MC-16/16H only allows this setup in the debugging mode.

- Emulation Memory Area

Memory space substituted for emulator memory is called the emulation memory area, and this memory is called emulation memory.

As emulation memory area, Using MB2145-506 emulation pod, up to seven areas (including mirror area and internal ROM area described below) each with a maximum size of 64 KB can be set. An area larger than 64 KB can be set, but the areas are managed internally in 64 KB units.

Using MB2145-507 emulation pod, up to seven areas (including mirror area and internal ROM area described below) each with a maximum size of 512 KB can be set.

The memory operation command can be executed for this area while executing MCU.

To set the emulation memory area, use the SET MAP command. Attributes are set as for user memory area.

Note:

Even if the MCU internal resources are set as emulation memory area, access is made to the internal resources. The F^2MC-16/16H only allows this setup in the debugging mode.

- Mirror Area

The mirror area is a region in the emulator memory that makes copies of user memory accesses. The memory in this area is called a mirror region.

The mirror area is used while it overlaps with a user memory area or undefined area. It is implemented by the emulation memory. Up to five mirror areas can be defined including emulation memory areas.

Mirror areas are used to reference the user memory during on-the-fly execution (For further details, refer to Section "2.2.4 On-the-fly Memory Access").

Mirror areas can be set using the SET MAP command. If the memory contents copy option is selected when a mirror area is set, the contents of the mirror area are always the same contents as the user memory.

Note:

When the F^{2}MC-16/16H is used, mirror area setup can be performed only in the debugging mode.

- Internal ROM Area

The area where the emulator internal memory is substituted for internal ROM is called the internal ROM area, and this memory is called the internal ROM memory.

Only one internal ROM area with a size up to 128 KB can be specified. The internal ROM area is capable to set by the "Setup Map" dialog opening by "Debugger Memory Map... " from "Setup".

Note:

The internal memory area, it is set a suitable area automatically by the selected MCU.

- Internal ROM Image Area (F^{2}MC-16L, F^{2}MC-16LX, F^{2}MC-16F only)

Some types of MCUs have data in a specific area of internal ROM appearing to 00 bank. This specific area is called the internal ROM image area.

The internal ROM image area is capable to set by the "Setup Map" dialog opening by "Debugger Memory Map... " from "Setup". This area attribute is automatically set to READ/CODE. The same data as in the internal ROM area appears in the internal ROM image area.

Note that the debug information is only enabled for either one (one specified when linked). To debug only the internal ROM image area, change the creation type of the load module file.

Note:

The internal memory area, it is set a suitable area automatically by the selected MCU.

- Internal Instruction RAM Area (F^{2}MC-16H only)

Some types of MCUs have the internal instruction RAM, and this area is called the internal instruction RAM area.

The internal instruction RAM area, it is capable to set by the "Internal Instruction RAM area" tab in the "Setup CPU Information" dialog (select menu "project"-"setup project...", select the "MCU" tab, and push the "CPU Information..." button). The size must be specified to either H'100, H'200, H'400, H'800, H'1000, H'2000 or H'4000 bytes.

Note:

The internal memory area, it is set a suitable area automatically by the selected MCU.

- Undefined Area

A memory area that does not belong to any of the areas described above is part of the user memory area. This area is specifically called the undefined area.

The undefined area can be set to either NOGUARD area, which can be accessed freely, or GUARD area, which cannot be accessed. Select either setup for the whole undefined area. If the area attribute is set to GUARD, a guarded access error occurs if access to this area is attempted.

Note:

The F^2MC-16/16H only allows this setup in the debugging mode.

2.2.1.4 Memory Mapping

Memory space can be allocated to the user memory, the emulation memory, etc., and the attributes of these areas can be specified.
However, the MCU internal resources are not dependent on this mapping setup and access is always made to the internal resources.

■ Access Attributes for Memory Areas

The access attributes shown in Table 2.2-2 can be specified for memory areas.

A guarded memory access break occurs if access is attempted in violation of these attributes while executing a program.

When access to the user memory area and the emulation memory area is made using program commands, such access is allowed regardless of the CODE, READ, WRITE attributes. However, access to memory with the GUARD attribute in the undefined area, causes an error.

Table 2.2-2 Types of Access Attributes

Area	Attribute	Description
User Memory Emulation Memory	CODE	Instruction Execution Enabled
	READ	Data Read Enabled
	WRITE	Data Write Enabled
Undefined	GUARD	Access Disabled
	NOGUARD	No check of access attribute

When access is made to an area without the WRITE attribute by executing a program, a guarded access break occurs after the data has been rewritten if the access target is the user memory. However, if the access target is the emulation memory, the break occurs before rewriting. In other words, write-protection (memory data cannot be overwritten by writing) can be set for the emulation memory area by not specifying the WRITE attribute for the area.

This write-protection is only enabled for access made by executing a program, and is not applicable to access by commands.

■ Creating and Viewing Memory Map

Use the following commands for memory mapping.

SET MAP: Set memory map.

SHOW MAP: Display memory map.

CANCEL MAP: Change memory map setting to undefined.

[Example]

```
 >SHOW MAP
address               attribute         type
000000 .. FFFFFF      noguard
The rest of setting area numbers
user = 8     emulation = 5
 >SET MAP/USER H'0..H'1FF
 >SET MAP/READ/CODE/EMULATION H'FF0000..H'FFFFFF
 >SET MAP/USER H'8000..H'8FFF
 >SET MAP/MIRROR/COPY H'8000..H'8FFF
 >SET MAP/GUARD
 >SHOW MAP
address               attribute         type
000000 .. 0001FF      read write        user
000200 .. 007FFF      guard
008000 .. 008FFF      read write        user
009000 .. FEFFFF      guard
FF0000 .. FFFFFF      read write code   emulation
mirror address area
008000 .. 008FFF      copy
The rest of setting area numbers
user = 6     emulation = 3
 >
```

■ Internal ROM Area Setting

The [Setup Map] dialog box is displayed using [Environment] - [Debugger Memory Map] menu. You can set the internal ROM area using the [Internal ROM Area] tab after the [Map Adding] dialog box is displayed by clicking on the [Setting] button. Two areas can be set. Both ones require empty Emulation area to be set. Require empty area is shown below.

(Empty space of the emulation area) × (one area size)

You can specify the size up to the size shown above.

Specify the internal ROM area from the ending address H'FFFFFF (fixed) for area 1. Also, it is possible to delete the internal ROM area.

2.2.1.5 Timer Minimum Measurement Unit

The timer minimum measurement unit affects the sequencer, the emulation timer and the performance measurement timer.

■ Setting Timer Minimum Measurement Unit

Choose either 1 μs or 100 ns as the timer minimum measurement unit for the emulator for measuring time.

The minimum measurement unit for the following timers is changed depending on this setup.

- Timer values of sequencer (timer conditions at each level)
- Emulation timer
- Performance measurement timer

Table 2.2-3 shows the maximum measurement time length of each timer when 1 μs or 100 ns is selected as the minimum measurement unit.

When the minimum measurement unit is changed, the measurement values of each timer are cleared as well. The default setting is 1 μs.

Table 2.2-3 Maximum Measurement Time Length of Each Timer

	1 μs selected	100 ns selected
Sequencer timer	About 16 seconds	About 1.6 seconds
Emulation timer	About 70 minutes	About 7 minutes
Performance measurement timer	About 70 minutes	About 7 minutes

Use the following commands to control timers.

SET TIMERSCALE : Sets minimum measurement unit for timers

SHOW TIMERSCALE : Displays status of minimum measurement unit setting for timers

[Example]

```
>SET TIMERSCALE/100N
>SHOW TIMERSCALE
Timer scale : 100ns
>
```

2.2.2 Notes on Commands for Executing Program

When using commands to execute a program, there are several points to note.

■ Notes on GO Command

For the GO command, two breakpoints that are valid only while executing commands can be set. However, it is required to be careful in setting these breakpoints.

- Invalid Breakpoints

No break occurs when a breakpoint is set at the instruction immediately after the following instructions.

F^2MC-16L/16LX/16/16H	PCB NCC SPB MOV ILM,#imm8 OR CCR,#imm8	DTB ADB CNR AND CCR,#imm8 POPW PS
F^2MC-16F	PCB NCC SPB	DTB ADB CNR

- No break occurs when breakpoint set at address other than starting address of instruction.
- No break occurs when both following conditions met at one time.
- Instruction for which breakpoint set starts from odd-address,
- Preceding instruction longer than 2 bytes length, and breakpoint already set at last 1-byte address of preceding instruction (This "already-set" breakpoint is an invalid breakpoint that won't break, because it has been set at an address other than the starting address of an instruction).

- Abnormal Breakpoint

Setting a breakpoint at the instruction immediately after string instructions listed below, may cause a break in the middle of the string instruction without executing the instruction to the end.

F^2MC-16L/16LX/16/16H	MOVS SECQ WBTS MOVSWI SECQWI MOVSD SECQD FILS FILSW	MOVSW SECQW MOVSI SECQI WBTC MOVSWD SECQWD FILSI FILSWI
F^2MC-16F	MOVS SECQ WBTS MOVSWI SECQWI MOVSD SECQD FILS FILSW MOVM	MOVSW SECQW MOVSI SECQI WBTC MOVSWD SECQWD FILSI FILSWI MOVMW

■ Notes on STEP Command

- Exceptional Step Execution

When executing the instructions listed in the notes on the GO command as invalid breakpoints and abnormal breakpoints, such instructions and the next instruction are executed as a single instruction. Furthermore, if such instructions are continuous, then all these continuous instructions and the next instruction are executed as a single instruction.

- Step Execution that won't Break

Note that no break occurs after step operation when both the following conditions are met at one time.

- When step instruction longer than 2 bytes and last code ends at even address
- When breakpoint already set at last address (This "already-set" breakpoint is an invalid breakpoint that won't break, because it has been set at an address other than the starting address of an instruction.)

■ Controlling Watchdog Timer

It is possible to select "No reset generated by watchdog timer counter overflow" while executing a program using the GO, STEP, CALL commands.

Use the ENABLE WATCHDOG, DISABLE WATCHDOG commands to control the watchdog timer.

- ENABLE WATCHDOG : Reset generated by watchdog timer counter overflow
- DISABLE WATCHDOG : No reset generated by watchdog timer counter overflow

The start-up default in this program is "Reset generated by watchdog timer counter overflow".

[Example]

```
>DISABLE WATCHDOG
>GO
```

2.2.3 Commands Available during Execution of User Program

This section explains the commands available during the execution of a user program.

■ Commands Available during Execution of User Program

This emulator debugger allows you to use certain commands during the execution of a user program.

For more details, see "■ Debugger" in "SOFTUNE Workbench Command Reference Manual".

The double circle indicates that it is available during the execution of a user program.

Table 2.2-4 shows the commands available during the execution of a user program.

Table 2.2-4 Commands Available during Execution of User Program

Function	Restrictions	Major Commands
MCU reset	-	1.3 RESET
Memory operation (Read/Write)	Emulation memory only operable Read only enabled in mirror area	5.1 EXAMINE, 5.2 ENTER, 5.3 SET MEMORY, 5.4 SHOW MEMORY, 5.5 SEARCH MEMORY, 5.8 COMPARE, 5.9 FILL, 5.10 MOVE, 5.11 DUMP
Line assembly, Disassembly	Emulation memory only enabled Mirror area, Disassembly only enabled	6.1 ASSEMBLE, 6.2 DISASSEMBLE
Displaying coverage measurement data	-	4.19 SHOW COVERAGE
Displaying event	Disabled in performance mode	3.23 SHOW EVENT

Notes:

- The conditions which allow you to use the commands in Table 2.2-4 are limited to the following cases when a user program is executed.
  - [Debug] - [Run] - [Go] menu
  - [Go] button on the debug toolbar

  The commands in Table 2.2-4 cannot be used when the GO command is entered in the command window.
- An error message appears if you enter a command that cannot be used during the execution of a user program.

  "E4404S Command error (MCU is busy)."

2.2.4 On-the-fly Memory Access

While on-the-fly, the area mapped to the emulation memory is Read/Write enabled, but the area mapped to the user memory area is Read-only enabled.

■ Read/Write Memory while On-the-fly

The user memory cannot be accessed while on-the-fly (when execute the MCU). However, the emulation memory can be accessed. (The using cycle-steal algorithm eliminates any negative effect on the MCU speed.)

This emulator allows the user to use part of the emulation memory as a mirror area. The mirror area holds a copy of the user memory. Using this mirror area makes the Read-only enabled function available while on-the-fly.

Each memory area operates as follows:

- User Memory Area

Access to the user memory is permitted only when the operation is suspended by a break.

- Emulation Memory Area

Access to the emulation memory is permitted regardless of whether the MCU is suspended, or while on-the-fly.

- Mirror Area

The emulation memory with the MIRROR setting can be set up for the user memory area to be referred to while on-the-fly. This area is specifically called the mirror area.

As shown in Figure 2.2-1, the mirror area performs access to the user memory while the MCU is stopped, and such access is reflected simultaneously in the emulation memory specified as the mirror area. (Read access is also reflected in the emulation memory specified as the mirror area).

In addition, as shown in Figure 2.2-2, access to the user memory by the MCU is reflected "as it is" in the emulation memory of the mirror area.

While on-the -fly, the user memory cannot be accessed. However, the emulation memory specified as the mirror area can be read instead. In other words, identical data to that of the user memory can be read by accessing the mirror area.

However, at least one time access must be allowed before the emulation memory of the mirror area has the same data as the user memory. The following copy types allow the emulation memory of the mirror area to have the same data as the user memory.

(1) Copying all data when setting mirror area
When, /COPY is specified with the mirror area set using the SET MAP command, the whole area is specified, as the mirror area is copied.

(2) Copying only required portion using memory access commands
Data in the specified portion can be copied by executing a command that accesses memory.

The following commands access memory.

- Memory operation commands

SET MEMORY, SHOW MEMORY, EXAMINE, ENTER,
COMPARE, FILL, MOVE, SEARCH MEMORY, DUMP,
COPY, VERIFY

- Data load/save commands

LOAD, SAVE

Figure 2.2-1 Access to Mirror Area while MCU Suspended

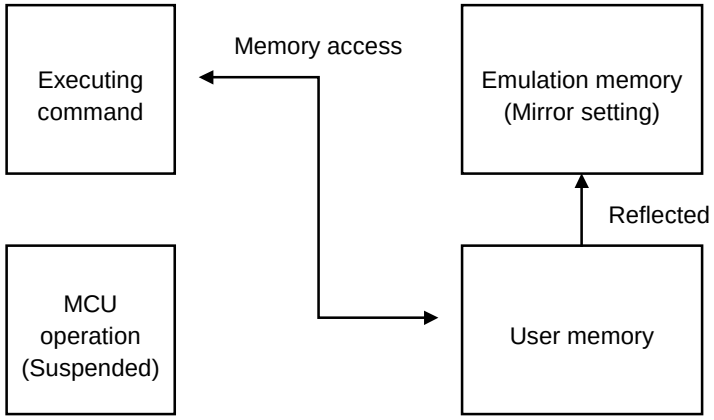
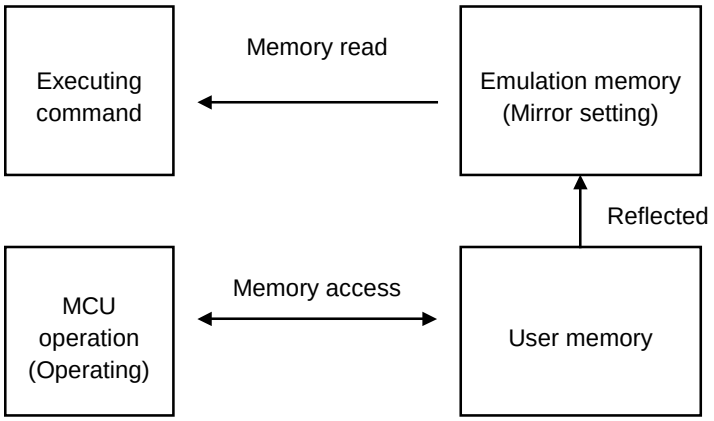


Figure 2.2-2 On-the-fly Access to Mirror Area



Note:

Memory access by a bus master other than the MCU is not reflected in the mirror area.

2.2.5 Break

In this emulator debugger, seven types of break functions can be used. When the program execution is aborted by each break function, the address and the break factor to do the break are displayed.

■ Break Functions

In this emulator debugger, the following seven types of break functions are supported.

- Code break
- Data break
- Sequential break
- Guarded access break
- Trace-buffer-full break
- Performance-buffer-full break
- Forced break

2.2.5.1 Code Break

It is a function to abort the program execution by observing the specified address. The break is done before an instruction the specified address is executed.

■ Code Break

It is a function to abort the program execution by observing the specified address. The break is done before an instruction the specified address is executed. It is possible to set it in this 65535 debuggers. However, it is necessary to set the debugging area as a code break area.

When a break occurs due to a code break, the following message is displayed on the Status Bar.

Break at Address by breakpoint

■ Setting Method

The code break is controlled by the following method.

- Command
  - SET BREAK
    Refer to "3.1 SET BREAK (type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Breakpoints set dialog [Code] tab
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".
- Window
  - Source window/Disassembly window

■ Notes on Code Break

There are several points to note in using code break. First, some points affecting code break are explained.

● Invalid Breakpoints

- No break occurs when a breakpoint is set at the instruction immediately after the following instructions.

  F^2MC-16/16L/16LX/16H: • PCB • DTB • NCC • ADB • SPB • CNR
  • MOV ILM,#imm8 • AND CCR,#imm8
  • OR CCR,#imm8 • POPW PS

  F^2MC-16F: • PCB • DTB • NCC • ADB • SPB • CNR
- No break occurs when breakpoint set at address other than starting address of instruction.
- No break occurs when both following conditions met at one time.
  - Instruction for which breakpoint set starts from odd-address
  - Preceding instruction longer than 2 bytes length, and breakpoint already set at last 1-byte address of preceding instruction (This "already-set" breakpoint is an invalid breakpoint that won't break, because it has been set at an address other than the starting address of an instruction.)

● Abnormal Breakpoint

- Setting a breakpoint at the instruction immediately after string instructions listed below, may cause a break in the middle of the string instruction without executing the instruction to the end.

F^2MC-16/16L/16LX/16H:	• MOVS	• MOVSW	• SECQ	• SECQW	• WBTS
	• MOVSI	• MOVSWI	• SECQI	• SECQWI	• WBTC
	• MOVSD	• MOVSWD	• SECQD	• SECQWD	
	• FILS	• FILSI	• FILSW	• FILSWI	
F^2MC-16F: Above plus	• MOVM	• MOVMW			

Here are some additional points about the effects on other commands.

● Dangerous Breakpoints

Never set a breakpoint at an address other than the instruction starting address. If a breakpoint is the last 1 byte of an instruction longer than 2 bytes length, and if such an address is even, the following abnormal operation will result:

- If instruction executed by STEP command, instruction execution not aborted.
- If breakpoint specified with GO command, set at instruction immediately after such instruction, the breakpoint does not break.

Note:

When the debugging area is set again, all breakpoints in the area are cleared.

2.2.5.2 Data Break

The data break is a function to abort the program execution when the data access (read or write) is done to the address specified while executing the program.

■ Data Break

The data break is a function to abort the program execution when MCU accesses data as for a specified address.

When a break occurs due to a data break, the following message is displayed on the Status Bar.

Break at Address by databreak at Access address

The number to which the data break can be set is as follows.

In debugging area of data attribute: 65535 pieces

Other areas:6 pieces

■ Setting Method

The data break is controlled by the following method.

- Command
  - SET DATABREAK
    Refer to "3.10 SET DATABREAK (type 2)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Breakpoints set dialog [Data] tab
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".

Note:

When the debugging area is set again, all breakpoints in the area are cleared.

2.2.5.3 Sequential Break

A sequential break is a function to abort a executing program, when the sequential condition is met by event sequential control.

■ Sequential Break

It is a function to discontinue the program execution when the sequential condition consists by the sequential control of the event. Use a sequential break when the event mode is set to normal mode using the SET MODE command.

When a break occurs due to a sequential break, the following message is displayed on the Status Bar.

Break at Address by sequential break (level = Level No.)

For details of the sequential break function, refer to Section "2.2.7 Control by Sequencer".

■ Setting Method

The sequential break is controlled by the following method.

1. Set event mode (SET MODE)
2. Set events (SET EVENT)
3. Set sequencer (SET SEQUENCE)

2.2.5.4 Guarded Access Break

The guarded access break is an abortion of the program execution that happens when the violation to the set access attribute, doing the access, and guarded (An undefined area cannot be accessed) area are accessed.

■ Guarded Access Break

A guarded access break aborts a executing program when access is made in violation of the access attribute set by using the [Setup] - [Memory Map] menu, and access is attempted to a guarded area (access-disabled area in undefined area).

There are three types of the following in Guarded access break.

Code guarded

When the instruction execution is done to the area without the code attribute, the break is done.

Read guarded

When the area without the read attribute is read, the break is done.

Write guarded

When the area without the write attribute is write, the break is done.

If a guarded access occurs while executing a program, the following message is displayed on the Status Bar and the program is aborted.

Break at Address by guarded access {code/read/write} at Access address

Note:

Code Guarded is affected by pre-fetching.

The F^2MC-16L/16LX/16/16H family pre-fetch up to 4 bytes. So, when setting the program area mapping, set a little larger area (5 bytes max.) than the program area actually used.

Similarly, the F^2MC-16F family pre-fetch up to 8 bytes. So, when setting the program area mapping, set a little larger area (9 bytes max.) than the program area actually used.

2.2.5.5 Trace-Buffer-Full Break

It is a function to abort the program execution when the trace buffer becomes full.

■ Trace-Buffer-Full Break

It is a function to abort the program execution when the trace buffer becomes full.

When a break occurs due to a trace-buffer-full break, the following message is displayed on the Status Bar.

Break at Address by trace buffer full

■ Setting Method

The trace-buffer-full break is controlled by the following method.

- Command
  - SET TRACE/BREAK
    Refer to "4.29 SET TRACE (type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Trace Set Dialog
    Refer to "4.4.8 Trace" in "SOFTUNE Workbench Operation Manual".

2.2.5.6 Performance-Buffer-Full Break

It is a function to abort the program execution when the buffer for the performance measurement data storage becomes full.

■ Performance-Buffer-Full Break

It is a function to abort the program execution when the buffer for the performance measurement data storage becomes full.

When a break occurs due to a performannce-buffer-full break, the following message is displayed on the Status Bar.

Break at Address by performance buffer full

■ Setting Method

The performance-buffer-full break is controlled by the following method.

- Command
  - SET PERFORMANCE/BREAK
    Refer to "4.7 SET PERFORMANCE (type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Performance set dialog
    Refer to "4.4.13 Performance" in "SOFTUNE Workbench Operation Manual".

2.2.5.7 Forced Break

It is a function to abort the execution of the program compulsorily.

■ Forced Break

It is a function to abort the execution of the program compulsorily.

When a break occurs due to a forced break, the following message is displayed on the Status Bar.

Break at Address by command abort request

Note:

A forced break is not allowed while the MCU is in the low-power consumption mode or hold state. When a forced break is requested by the [Debug] - [Abort] menu while executing a program, the menu is disregarded if the MCU is in the low-power consumption mode or hold state. If a break must occur, then reset the cause at user system side, or reset the cause by using the [Debug] - [Reset MCU] menu, after inputting the [Debug] - [Abort] menu.

When the MCU enters the power-save consumption mode or hold state while executing, the status is displayed on the Status Bar.

2.2.6 Events

The emulator can monitor the MCU bus operation, and generate a trigger at a specified condition called an event.
In this emulator, event triggers are used in order to determine which function event triggers are used accounting to event modes for the following functions;

- **Sequencer**
- **Sampling condition for multi-trace**
- **Measuring point in performance measurement**

■ Setting Events

Eight events or less can be set.

Table 2.2-5 shows the conditions that can be set for events.

Table 2.2-5 Conditions for Setting Events

Condition	Description
Address	Memory location (Address bit masking enabled)
Data	8-bit data (data bit masking enable) NOT specified enable
Status	Select from among dada read, data write, instruction execution and data modify.
External Probe	8-bit data (bit masking enable)

Notes:

- In instruction execution, an event trigger is generated only when an instruction is executed. This status cannot be specified concurrently with other status.
- The data modify is a function to generate the event trigger when the data of a specified address rewrites. When the data modify is specified for status, the data specification is disregarded. This status cannot be specified concurrently with other status.

Use the following commands to set an event.

SET EVENT:	Sets event
SHOW EVENT:	Display event setup status
CANCEL EVENT:	Deletes event
ENABLE EVENT:	Enable event
DISABLE EVENT:	Disable event

[Example]

```
>SET EVENT  1,func1
>SET EVENT/WRITE 2,data[2],!d=h'10
>SET EVENT/MODIFY 3,102
```

An event can be set in the Event window as well.

■ Event Modes

There are three event modes as listed below. To determine which function event triggers are used for, select one using the SET MODE command. The default is normal mode.

The event value setting are made for each mode, so switching the event mode changes the event settings as well.

- Normal Mode

Event triggers used for sequencer.

Since the sequencer can perform control at 8 levels, it can control sequential breaks, time measurement and trace sampling. Real-time tracing in the normal mode is performed by single trace (tracing function that samples program execution continuously).

- Multi Trace Mode

Event triggers used for multitracing (trace function that samples data before and after event trigger occurrence).

- Performance Mode

Event triggers are used for performance measurement to measure time duration between two event trigger occurrences and count of event trigger occurrences.

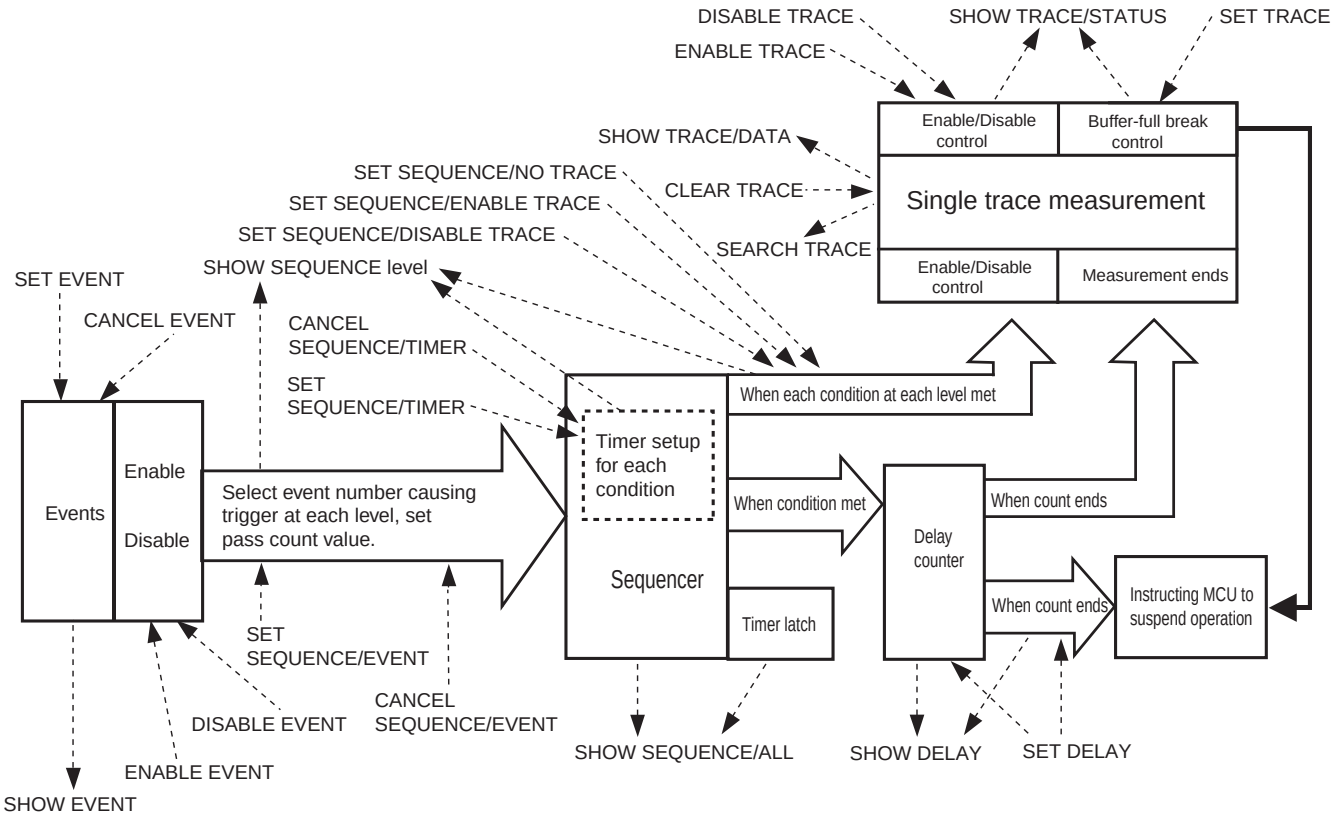
2.2.6.1 Operation in Normal Mode

As shown in the figure below, the event trigger set in the normal mode performs input to the sequencer. In the sequencer, either branching to any level, or terminating the sequencer, can be specified as an operation at event trigger occurrence. This enables debugging (breaks, limiting trace, measuring time) while monitoring program flow.

■ Operation in Normal Mode

The termination of sequencer triggers the delay counter. When the delay counter reaches the specified count, sampling for the single trace terminates. A break normally occurs at this point, but if necessary, the program can be allowed to run on without a break.

Figure 2.2-3 Operation in Normal Mode



■ Event-related Commands in Normal Mode

Since the real-time trace function in the normal mode is actually the single trace function, the commands can be used to control.

Table 2.2-6 shows the event-related commands that can be used in the normal mode.

Table 2.2-6 Event-related Commands in Normal Mode

Mode	Usable Command	Function
Normal Mode	SET EVENT SHOW EVENT CANCEL EVENT ENABLE EVENT DISABLE EVENT	Set event Displays event setup status Delete event Enables event Disables event
	SET SEQUENCE SHOW SEQUENCE CANCEL SEQUENCE ENABLE SEQUENCE DISABLE SEQUENCE	Sets sequencer Displays sequencer setup status Cancels sequencer Enables sequencer Disables sequencer
	SET DELAY SHOW DELAY	Sets delay count Displays delay count setup status
	SET TRACE SHOW TRACE SEARCH TRACE ENABLE TRACE DISABLE TRACE CLEAR TRACE	Sets trace buffer-full break Displays trace data Searches trace data Enables trace function Disables trace function Clears trace data

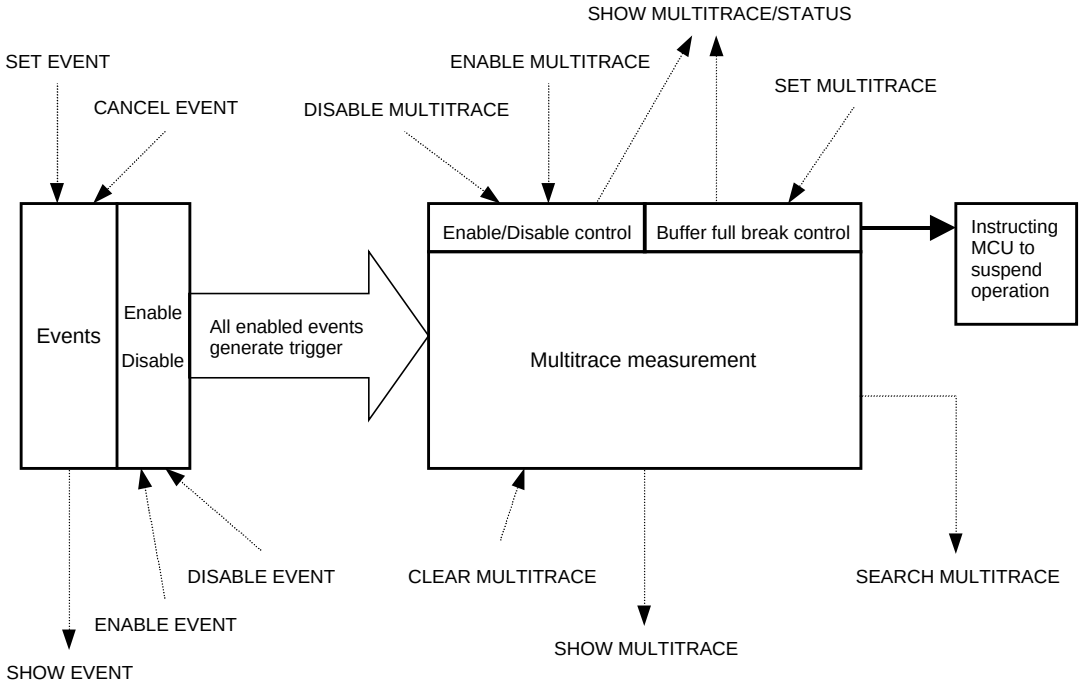
2.2.6.2 Operation in Multi Trace Mode

When the multi trace mode is selected as the event mode, the real-time trace function becomes the multi trace function, and events are used as triggers for multitracing.

■ Operation in Multi Trace Mode

Multitracing is a trace function that samples data before and after an event trigger occurrence. When the multi trace mode is selected as the event mode, the real-time trace function becomes the multi trace function, and events are used as triggers for multitracing.

Figure 2.2-4 Operation in Multi Trace Mode



■ Event-related Commands in Multi Trace Mode

Table 2.2-7 shows the event-related commands that can be used in the multi-race mode.

Table 2.2-7 Event-related Commands in Multi Trace Mode

Mode	Usable Command	Function
Multi Trace Mode	SET EVENT SHOW EVENT CANCEL EVENT ENABLE EVENT DISABLE EVENT	Sets event Displays event setup status Deletes event Enables event Disables event
	SET MULTITRACE SHOW MULTITRACE SEARCH MULTITRACE ENABLE MULTITRACE DISABLE MULTITRACE CLEAR MULTITRACE	Sets trace buffer-full break Displays trace data Searches trace data Enables trace function Disables trace function Clears trace data

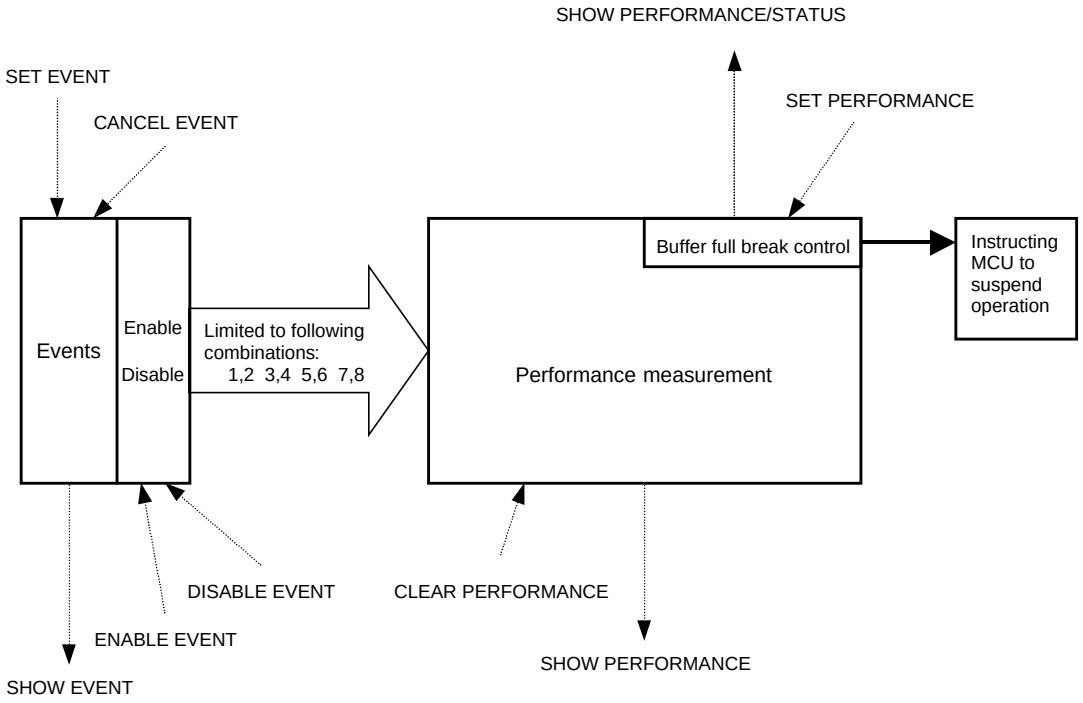
2.2.6.3 Operation in Performance Mode

Event triggers set in the performance mode are used to measure performance. The time duration between two event occurrences can be measured and the event occurrences can be counted.

■ Operation in Performance Mode

The event triggers that are set in the performance mode are used to measure performance. The time duration between two event occurrences can be measured and the event occurrences can be counted.

Figure 2.2-5 Operation in Performance Mode



■ Event-related Commands in Performance Mode

Table 2.2-8 shows the event-related commands that can be used in the performance mode.

Table 2.2-8 Event-related Commands in Performance Mode

Mode	Usable Command	Function
Performance Mode	SET EVENT SHOW EVENT CANCEL EVENT ENABLE EVENT DISABLE EVENT	Sets event Displays event setup status Deletes event Enables event Disables event
	SET PERFORMANCE SHOW PERFORMANCE CLEAR PERFORMANCE	Sets performance Displays performance setup status Clears performance measurement data

2.2.7 Control by Sequencer

This emulator has a sequencer to control events. By using this sequencer, sampling of breaks, time measurement and tracing can be controlled while monitoring program flow (sequence). A break caused by this function is called a sequential break.
To use this function, set the event mode to normal mode using the SET MODE command. Use the SET EVENT command to set events.

■ Control by Sequencer

As shown in Table 2.2-9, controls can be made at 8 different levels.

At each level, 8 events and 1 timer condition (9 conditions in total) can be set.

A timer condition is met when the timer count starts at entering a given level and the specified time is reached.

For each condition, the next operation can be specified when the condition is met. Select any one of the following.

- Move to required level.
- Terminate sequencer.

The conditions set for each level are determined by OR. Therefore, if any one condition is met, the sequencer either moves to the required level, or terminates. In addition, trace sampling abort/resume can be controlled when a condition is met.

Table 2.2-9 Sequencer Specifications

Function	Specifications
Level count	8 levels
Conditions settable for each level	8 event conditions (1 to 16777216 times pass count can be specified for each condition.) 1 timer condition (Up to 16 s. in 1 μs units or up to 1.6 s. in 100 ns units can be specified.*)
Operation when condition met	Branches to required level or terminates sequence. Controls trace sampling.
Other function	Timer latch enable at level branching
Operation when sequencer terminates	Starts delay counter

*: The minimum measurement unit for Timer value can be set to either 1 μs or 100 ns using the SET TIMERSCALE command.

2.2.7.1 Setting Sequencer

The sequencer operates in the following order:

(1) The sequencer starts from level 1 simultaneously with the start of program executing.

(2) Depending on the setting at each level, branching to the required level is performed when the condition is met.

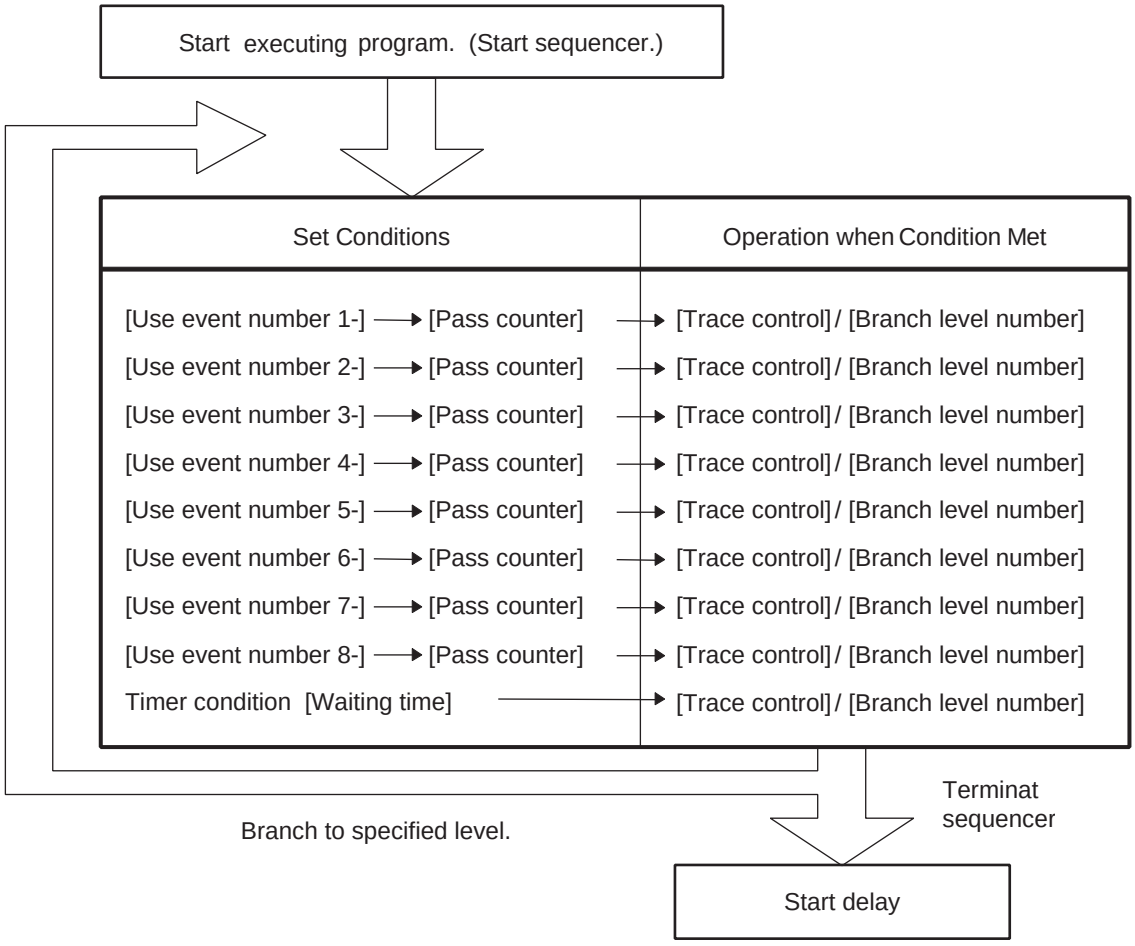
(3) When sequencer termination is specified, the sequencer terminates when the condition is met.

(4) When the sequencer terminates, the delay counter starts counting.

■ Setting Sequencer

Figure 2.2-6 shows the sequencer operation.

Figure 2.2-6 Operation of Sequencer



[Setup Examples]

- Terminate sequencer when event 1 occurs.

```
>SET SEQUENCE/EVENT 1,1,J=0
```

- Terminate sequencer when event 2 occurs 16 times.

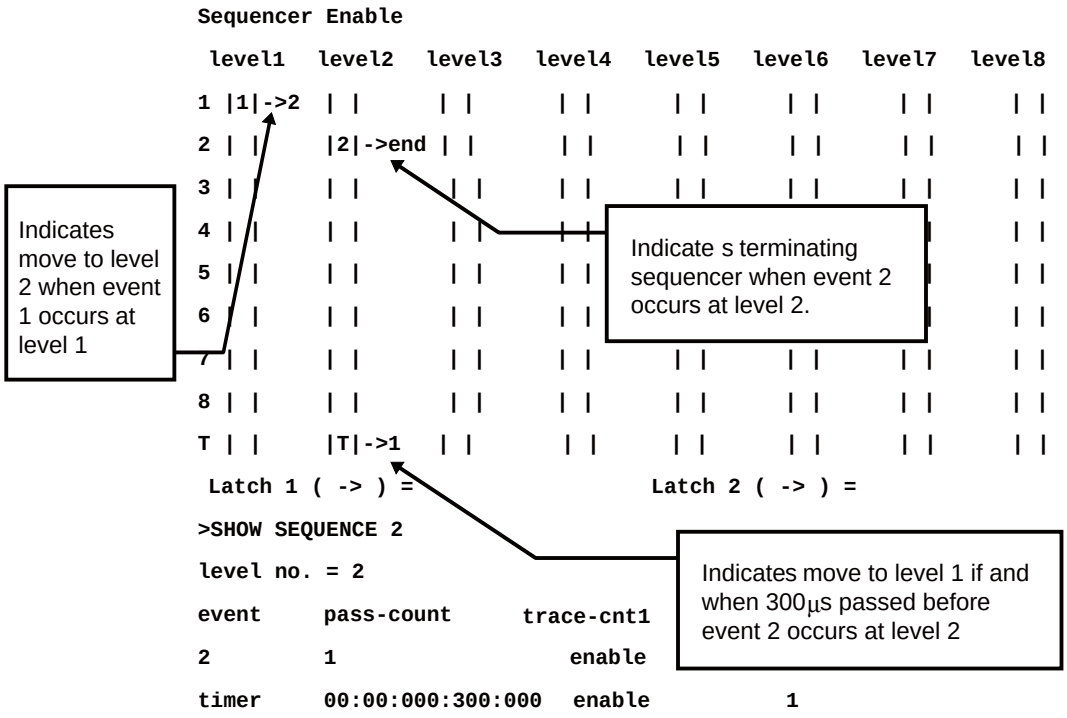
```
>SET SEQUENCE/EVENT 1,2,16,J=0
```

- Terminate sequencer when event 2 occurs after event 1 occurred. However, do not terminate sequencer if event 3 occurs between event 1 and event 2.

```
>SET SEQUENCE/EVENT 1,1,J=2
>SET SEQUENCE/EVENT 2,2,J=0
>SET SEQUENCE/EVENT 2,3,J=1
```

- Terminate sequencer if and when event 2 occurs less than 300 μs after event 1 occurred.

```
>SET SEQUENCE/EVENT 1,1,J=2
>SET SEQUENCE/EVENT 2,2,J=0
>SET SEQUENCE/TIMER 2,300,J=1
>SHOW SEQUENCE
```



2.2.7.2 Break by Sequencer

A program can suspend program execution when the sequencer terminates. This break is called a sequential break.

■ Break by Sequencer

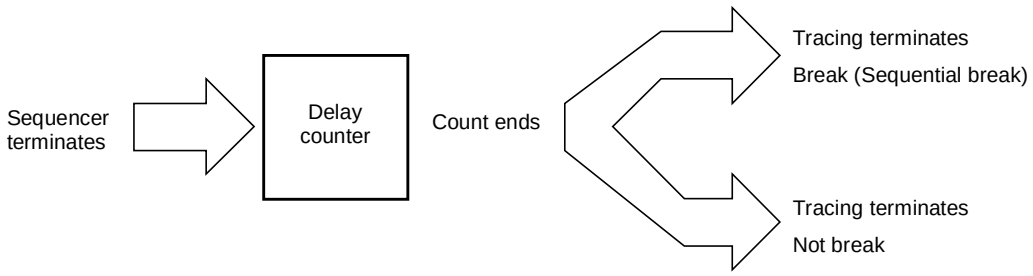
A program can suspend program execution when the sequencer terminates. This break is called a sequential break.

As shown in Figure 2.2-7, the delay count starts when the sequencer terminates, and after delay count ends, either "break" or "not break but tracing only terminates" is selected as the next operation.

To make a break immediately after the sequencer terminates, set delay count to 0 and specify "Break after delay count terminates". Use the SET DELAY command to set the delay count and the operation after the delay count.

The default is delay count 0, and Break after delay count.

Figure 2.2-7 Operation when sequencer terminates



[Examples of Delay Count Setups]

- Break when sequencer terminates.

```
>SET DELAY/BREAK 0
```

- Break when 100-bus-cycle tracing done after sequencer terminates.

```
>SET DELAY/BREAK 100
```

- Terminate tracing, but do not break when sequencer terminates.

```
>SET DELAY/NOBREAK 0
```

- Terminate tracing, but do not break when 100-bus-cycle tracing done after sequencer terminates.

```
>SET DELAY/NOBREAK 100
```

2.2.7.3 Trace Sampling Control by Sequencer

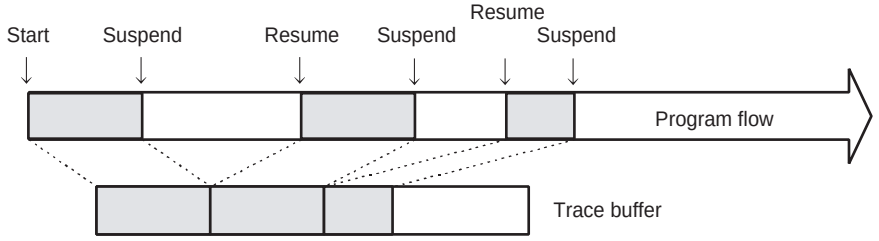
When the event mode is in the normal mode, real-time trace executing tracing called single trace.
If the trace function is enabled, single trace samples all the data from the start of executing a program until the program is suspended.

■ Trace Sampling Control by Sequencer

Sets up suspend/resume trace sampling for each condition at each level of the sequencer. Figure 2.2-8 shows the trace sampling flow.

For example, it is possible to suspend trace sampling when event 1 occurs, and then resume trace sampling when event 2 occurs. Trace data sampling can be restricted.

Figure 2.2-8 Trace Sampling Control (1)

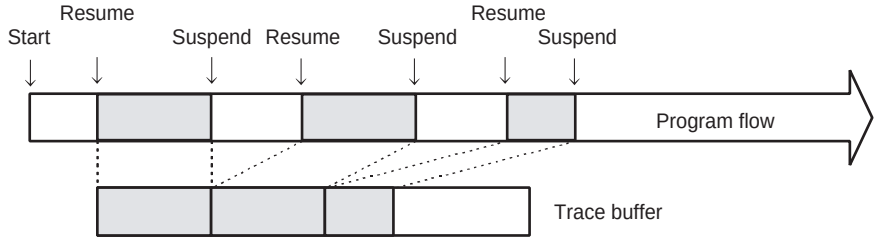


As shown in Figure 2.2-9, trace sampling can be disabled during the period from the start of a program execution until the first condition occurs. For this setup, use the GO command or the SET GO command.

[Example]

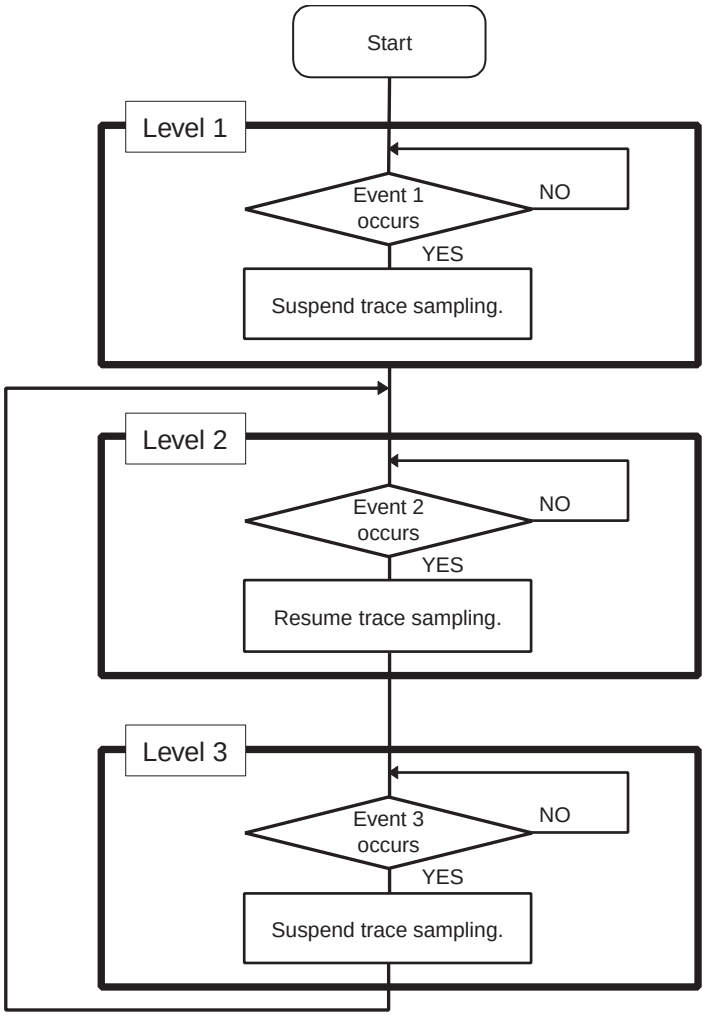
```
>GO/DISABLETRACE
>SET GO/DISABLETRACE
>GO
```

Figure 2.2-9 Trace Sampling Control (2)



[Setup Example]

Suspend trace sampling when event 1 occurs, and then resume at event 2 and keep sampling data until event 3 occurs.




```
>SET SEQUENCE/EVENT/DISABLETRACE 1,1,J=2
>SET SEQUENCE/EVENT/ENABLETRACE 2,2,J=3
>SET SEQUENCE/EVENT/DISABLETRACE 3,3,J=2
```

2.2.7.4 Time Measurement by Sequencer

Time can be measured using the sequencer. A time measurement timer called the emulation timer is used for this purpose. When branching is made from a specified level to another specified level, a timer value is specified. Up to two emulation timer values can be fetched. This function is called the timer latch function.

■ Time Measurement by Sequencer

The time duration between two given points in a complex program flow can be measured using the timer latch function.

The timing for the timer latch can be set using the SET SEQUENCE command; the latched timer values can be displayed using the SHOW SEQUENCE command.

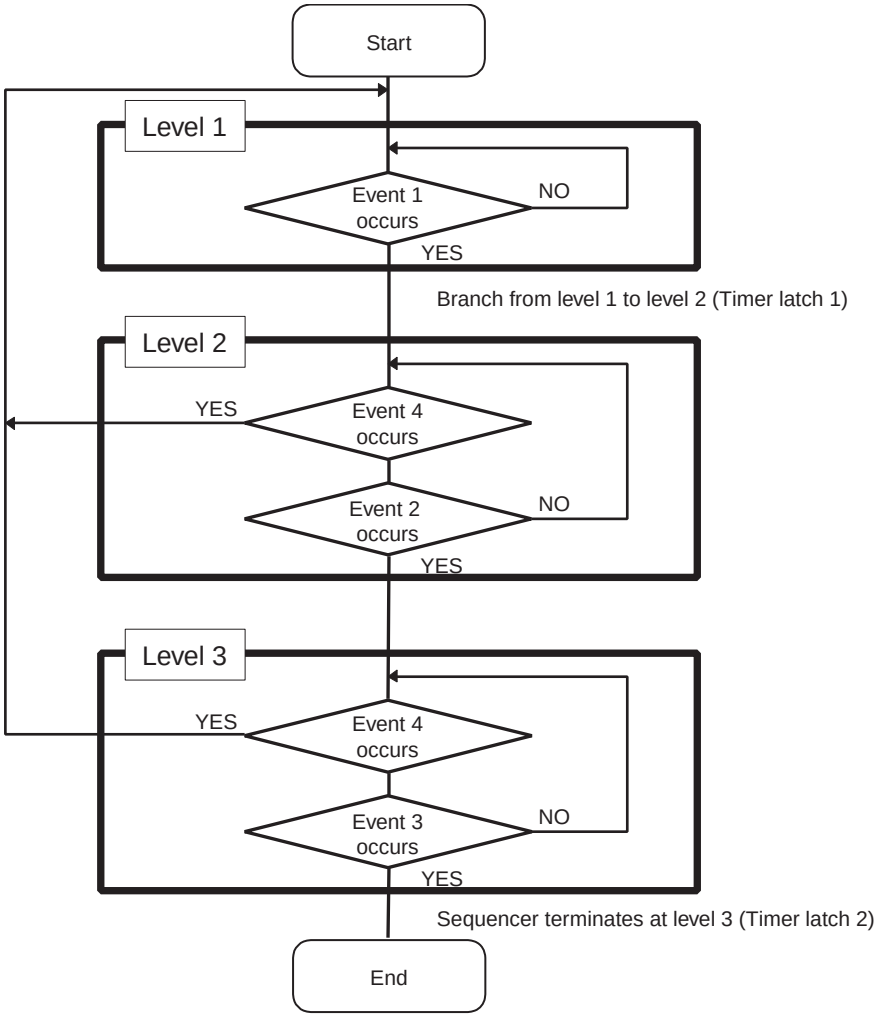
When a program starts execution, the emulation timer is initialized and then starts counting. Select either 1 μs or 100 ns as the minimum measurement unit for the emulation timer. Set the measurement unit using the SET TIMESCALE command.

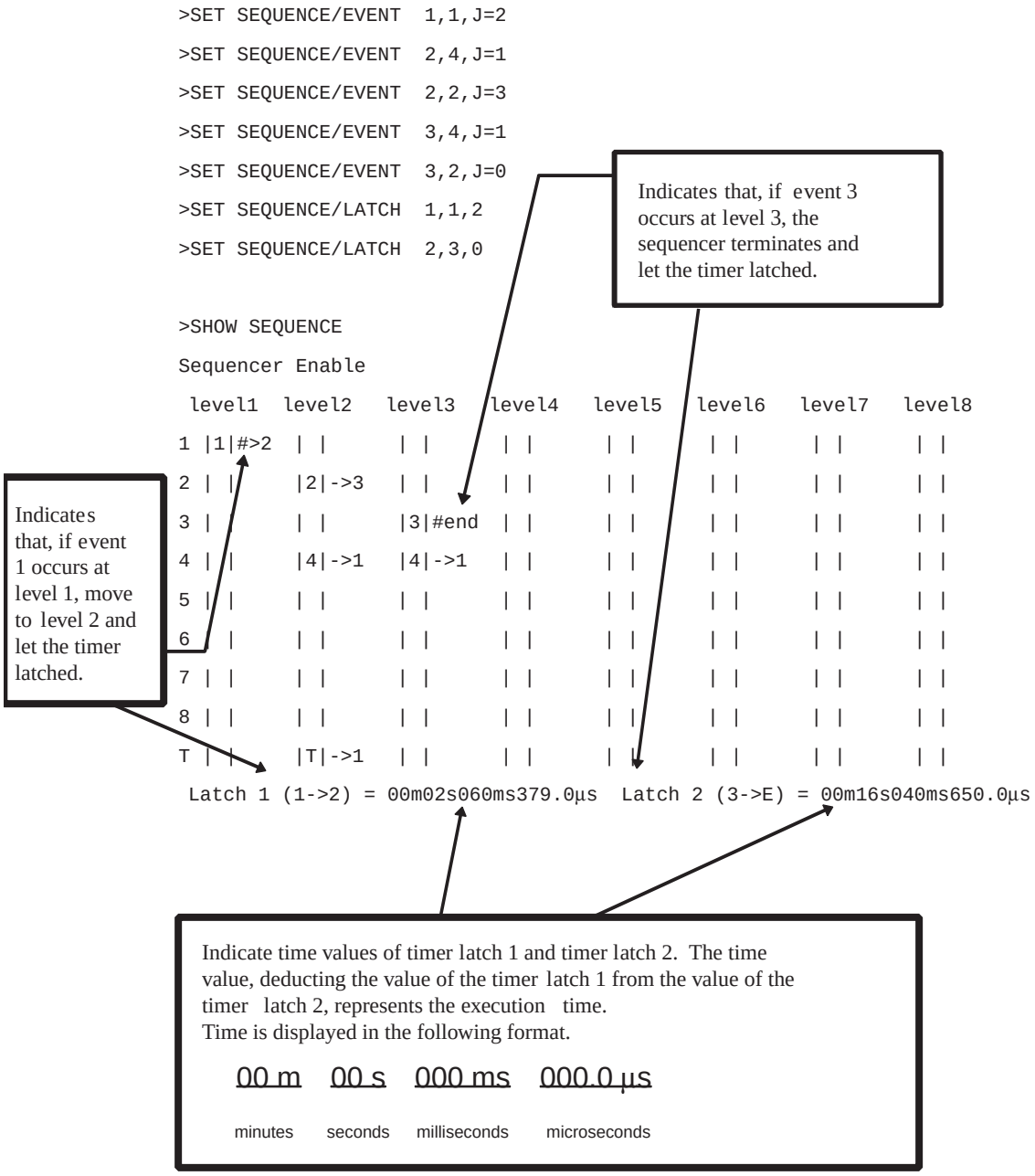
When 1 μs is selected, the maximum measured time is about 70 minutes; when 100 ns is selected, the maximum measured time is about 7 minutes. If the timer overflows during measurement, a warning message is displayed when the timer value is displayed using the SHOW SEQUENCE command.

2.2.7.5 Sample Flow of Time Measurement by Sequencer

In the following sample, when events are executed in the order of Event 1, Event 2 and Event 3, the execution time from the Event 1 to the Event 3 is measured. However, no measurement is made if Event 4 occurs anywhere between Event 1 and Event 3.

■ Sample Flow of Time Measurement by Sequencer




>SET SEQUENCE/EVENT 1,1,J=2
>SET SEQUENCE/EVENT 2,4,J=1
>SET SEQUENCE/EVENT 2,2,J=3
>SET SEQUENCE/EVENT 3,4,J=1
>SET SEQUENCE/EVENT 3,2,J=0
>SET SEQUENCE/LATCH 1,1,2
>SET SEQUENCE/LATCH 2,3,0
>SHOW SEQUENCE
Sequencer Enable
level1 level2 level3 level4 level5 level6 level7 level8
1 |1|#>2 | | | | | | | | | | | | | | | |
2 | | |2|->3 | | | | | | | | | | | |
3 | | | | |3|#end | | | | | | | | | |
4 | | |4|->1 |4|->1 | | | | | | | | | |
5 | | | | | | | | | | | | | | | |
6 | | | | | | | | | | | | | | | |
7 | | | | | | | | | | | | | | | |
8 | | | | | | | | | | | | | | | |
T | | |T|->1 | | | | | | | | | | | |
Latch 1 (1->2) = 00m02s060ms379.0µs Latch 2 (3->E) = 00m16s040ms650.0µs
Indicates that, if event 3 occurs at level 3, the sequencer terminates and let the timer latched.
Indicates that, if event 1 occurs at level 1, move to level 2 and let the timer latched.
Indicate time values of timer latch 1 and timer latch 2. The time value, deducting the value of the timer latch 1 from the value of the timer latch 2, represents the execution time.
Time is displayed in the following format.
00 m 00 s 000 ms 000.0 µs
minutes seconds milliseconds microseconds

2.2.8 Real-time Trace

While execution a program, the address, data and status information, and the data sampled by an external probe can be sampled in machine cycle units and stored in the trace buffer. This function is called real-time trace.
In-depth analysis of a program execution history can be performed using the data recorded by real-time trace.
There are two types of trace sampling: single trace, which traces from the start of executing the program until the program is suspended, and multi trace, which starts tracing when an event occurs.

■ Trace Buffer

The data recorded by sampling in machine cycle units, is called a frame.

The trace buffer can store 32K frames (32768). Since the trace buffer has a ring structure, when it becomes full, it automatically returns to the start to overwrite existing data.

■ Trace Data

Data sampled by the trace function is called trace data.

The following data is sampled:

- Address
- Data
- Status Information
  - Access status: Read/Write/Internal access, etc.
  - Device status: Instruction execution, Reset, Hold, etc.
  - Queue status: Count of remaining bytes of instruction queue, etc.
  - Data valid cycle information: Data valid/invalid
    (Since the data signal is shared with other signals, it does not always output data. Therefore, the trace samples information indicating whether or not the data is valid.)
- External probe data
- Sequencer execution level

■ Data Not Traced

The following data does not leave access data in the trace buffer.

- Data after tool hold

The F^2MC-16/16L/16LX/16H/16F family execute the following operation immediately after a break, etc., lets MCU suspend (a tool hold). This data is not displayed because it is deleted from the trace buffer.

- Access to address 100
- Access to FFFFDC to FFFFFF

- Portion of access data while native mode.

When operating in the native mode, the F^2MC-16/16L/16LX/16H/16F family of chips sometime performs simultaneous multiple bus operations internally. However, in this emulator, monitoring of the internal ROM bus takes precedence. Therefore, other bus data being accessed simultaneously may not be sampled (in the debugging mode, all operations are sampled).

2.2.8.1 Single Trace

The single trace traces all data from the start of executing a program until the program is aborted.

■ Function of Single Trace

The single trace is enabled by setting the event mode to normal mode using the SET MODE command.

The single trace traces all data from the start of executing a program until the program is suspended.

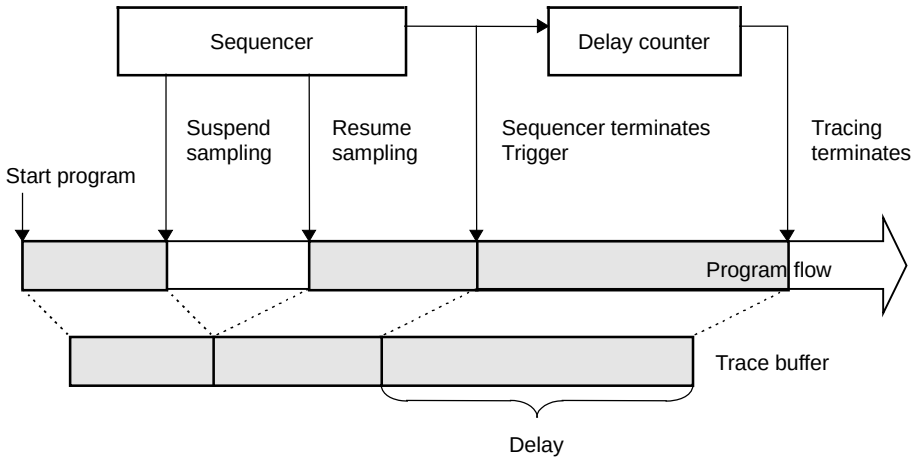
If the real-time trace function is enabled, data sampling continues execution to record the data in the trace buffer while the GO, STEP, CALL commands are being executed.

As shown in Figure 2.2-10, suspend/resume trace sampling can be controlled by the event sequencer. Since the delay can be set between the sequencer terminating the trigger and the end of tracing, the program flow after an given event occurrence can be traced. The delay count is counted in pass cycle units, so it matches the sampled trace data count. However, nothing can be sampled during the delay count if trace sampling is suspended when the sequencer is terminated.

After the delay count ends, a break occurs normally due to the sequential break, but tracing can be terminated without a break.

Furthermore, a program can be allowed to break when the trace buffer becomes full. This break is called a trace-buffer-full break.

Figure 2.2-10 Sampling in Single Trace



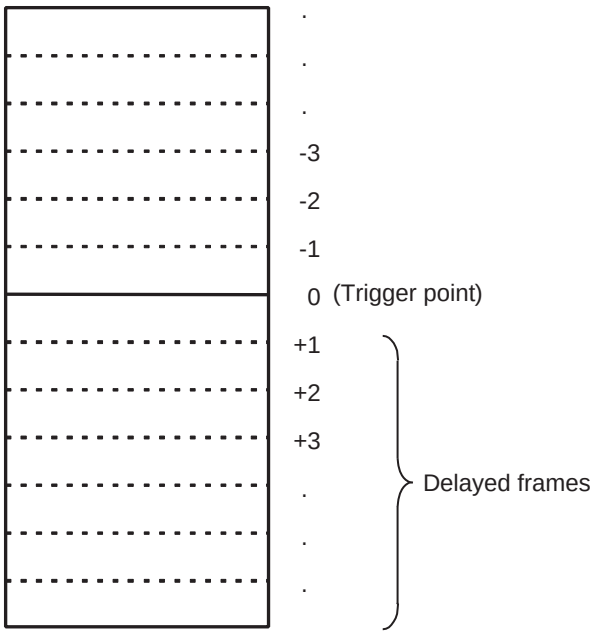
■ Frame Number and Step Number in Single Trace

The sampled trace data is numbered in frame units. This number is called the frame number.

When displaying trace data, the starting location in the trace buffer can be specified using the frame number. The trace data at the point where the sequencer termination trigger occurs is numbered 0; trace data sampled before reaching the trigger point is numbered negatively, and the data sampled after the trigger point is numbered positively (See Figure 2.2-11).

If there is no sequencer termination trigger point available, the trace data sampled last is numbered 0.

Figure 2.2-11 Frame Number in Single Trace



This program can analyze the single trace result and sort the buffer data in execution instruction units (only when the MCU execution mode is the debugging mode).

In this mode, the following information is grouped as one unit, and each information unit is numbered. This number is called the step number.

- Execution instruction mnemonic information
- Data access information
- Device status information

The step number at the sequencer termination trigger is numbered 0; information sampled before reaching the trigger point is numbered negatively, and information sampled after the trigger point is numbered positively.

If there is no sequencer termination trigger point, the information sampled last is numbered 0.

2.2.8.2 Setting Single Trace

The following settings (1) to (4) are required before executing single trace. Once these settings have been made, trace data is sampled when a program is executed.
(1) Set event mode to normal mode.
(2) Enable trace function.
(3) Set events, sequencer, and delay count.
(4) Set trace-buffer-full break.

■ Setting Single Trace

The following settings are required before executing single trace. Once these settings have been made, trace data is sampled when a program is executed.

(1) Set event mode to normal mode.

Use SET MODE command to make this setting.

(2) Enable trace function.

Use the ENABLE TRACE command. To disable the function, use the DISABLE TRACE command. The default is Enable.

(3) Set events, sequencer, and delay count.

Trace sampling can be controlled by setting the sequencer for events. If this function is not needed, there is no need of this setting.

To set events, use the SET EVENT command. To set the sequencer, use the SET SEQUENCE command.

Furthermore, set the delay count between sequencer termination and trace ending, and the break operation (Break or Not Break) when the delay count ends. If the data after event occurrence is not required, there is no need of this setting.

If Not Break is set, the trace terminates but no break occurs. To check trace data on-the-fly, use this setup by executing the SET DELAY command.

Note:

When the sequencer termination causes a break (sequential break), the last executed machine cycle is not sampled.

(4) Set trace-buffer-full break.

The program can be allowed to break when the trace buffer becomes full. Use the SET TRACE command for this setting. The default is Not Break. Display the setup status using the SHOW TRACE/STATUS command.

Table 2.2-10 lists trace-related commands that can be used in the single trace function.

Table 2.2-10 Trace-related Commands That Can Be Used in The Single Trace Function

Usable Command	Function
SET EVENT SHOW EVENT CANCEL EVENT ENABLE EVENT DISABLE EVENT	Sets events Displays event setup status Deletes event Enables event Disables event
SET SEQUENCE SHOW SEQUENCE CANCEL SEQUENCE ENABLE SEQUENCE DISABLE SEQUENCE	Sets sequencer. Displays sequencer setting status Cancels sequencer Enables sequencer Disables sequencer
SET DELAY SHOW DELAY	Sets delay count value, and operation after delay Displays delay count setting status
SET TRACE SHOW TRACE SEARCH TRACE ENABLE TRACE DISABLE TRACE CLEAR TRACE	Sets trace-buffer-full break Displays trace data Searches trace data Enables trace function Disables trace function Clears trace data

2.2.8.3 Multi trace

The multi trace samples data where an event trigger occurs for 8 frames before and after the event trigger.

■ Multi Trace Function

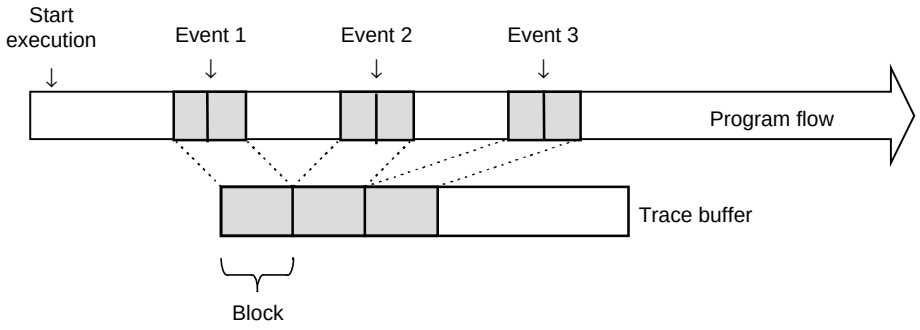
Execute multi trace by setting the event mode to the multi trace mode using the SET MODE command.

The multi trace samples data where an event trigger occurs for 8 frames before and after the event trigger.

It can be used for tracing required only when a certain variable access occurs, instead of continuous tracing.

The trace data sampled at one event trigger (16 frames) is called a block. Since the trace buffer can hold 32K frames, up to 2048 blocks can be sampled. Multi trace sampling terminates when the trace buffer becomes full. At this point, a executing program can be allowed to break if necessary.

Figure 2.2-12 Multi Trace Sampling



■ Multi Trace Frame Number

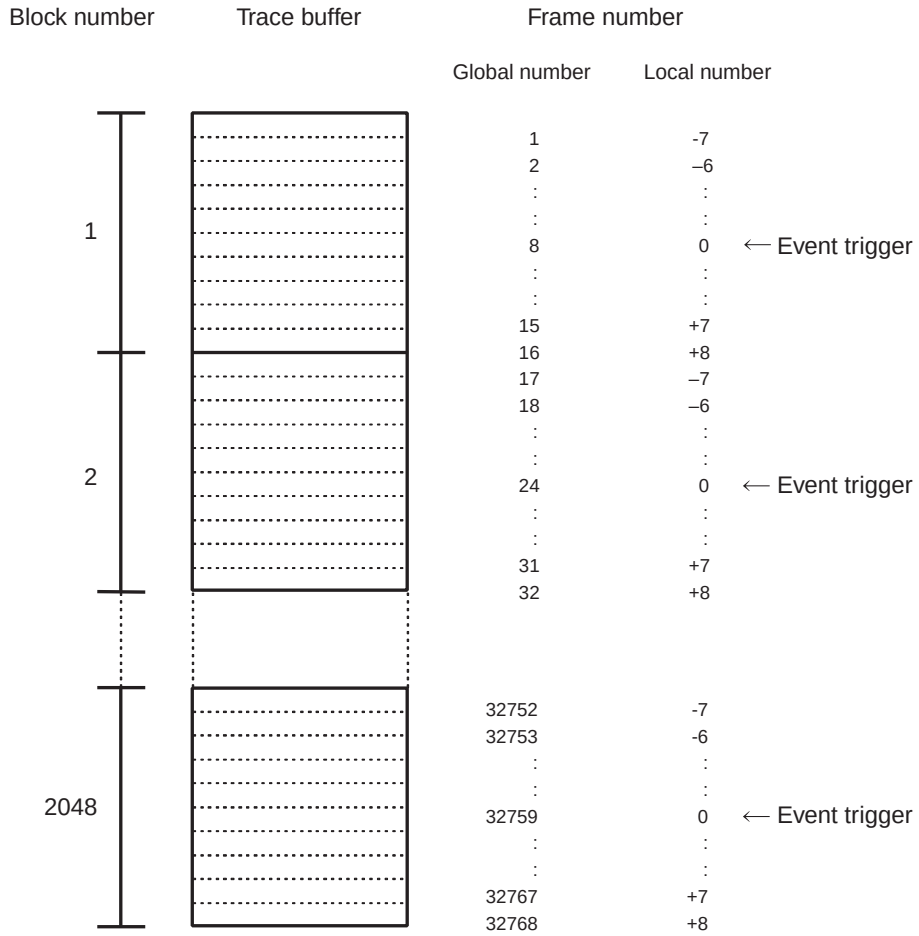
Sixteen frames of data are sampled each time an event occurs. This data unit is called a block, and each sampled block is numbered starting from 0. This is called the block number.

A block is a collection of 8 frames of sampled data before and after the event trigger occurs. At the event trigger is 0, trace data sampled before reaching the event trigger point is numbered negatively, and trace data sampled after the event trigger point is numbered positively. These frame numbers are called local numbers (See Figure 2.2-13).

In addition to this local number, there is another set of frame numbers starting with the oldest data in the trace buffer. This is called the global number. Since the trace buffer can hold 32K frames, frames are numbered 1 to 32768 (See Figure 2.2-13).

To specify which frame data is displayed, use the global number or block and local numbers.

Figure 2.2-13 Frame Number in Multi Trace



2.2.8.4 Setting Multi Trace

Before executing the multi trace, the following settings must be made. After these settings, trace data is sampled when a program is executed.
(1) Set event mode to multi trace mode.
(2) Enable trace function.
(3) Set event.
(4) Set trace-buffer-full break.

■ Setting Multi Trace

Before executing the multi trace, the following settings must be made. After these settings, trace data is sampled when a program is executed.

(1) Set event mode to multi trace mode.

Use the SET MODE command for this setting.

(2) Enable trace function.

Use the ENABLE MULTITRACE command. To disable the function, use the DISABLE MULTITRACE command.

(3) Set event.

Set an event that sampling. Use the SET EVENT command for this setting.

(4) Set trace-buffer-full break.

To break when the trace buffer becomes full, set the trace-buffer-full break. Use the SET MULTITRACE command for this setting.

Table 2.2-11 shows the list of trace-related commands that can be used in multi trace mode.

Table 2.2-11 Trace-related Commands That Can Be Used in Multi Trace Mode

Usable Command	Function
SET EVENT	Sets events
SHOW EVENT	Displays event setup status
CANCEL EVENT	Deletes event
ENABLE EVENT	Enables event
DISABLE EVENT	Disables event
SET MULTITRACE	Sets trace-buffer-full break
SHOW MULTITRACE	Displays trace data
SEARCH MULTITRACE	Searches trace data
ENABLE MULTITRACE	Enables multi trace
DISABLE MULTITRACE	Disables multi trace
CLEAR MULTITRACE	Clears trace data

2.2.8.5 Displaying Trace Data Storage Status

It is possible to Displays how much trace data is stored in the trace buffer. This status data can be read by specifying /STATUS to the SHOW TRACE command in the single trace mode, and to the SHOW MULTITRACE command in the multi trace mode.

■ Displaying Trace Data Storage Status

It is possible to Displays how much trace data is stored in the trace buffer. This status data can be read by specifying /STATUS to the SHOW TRACE command in the single trace mode, and to the SHOW MULTITRACE command in the multi trace.

Frame numbers displayed in the multi trace mode is the global number.

[Example]

- In Single Trace

```
 >SHOW TRACE/STATUS
en/dis      = enable         : Trace function enabled
buffer full = nobreak        : Buffer full break function disabled
sampling    = end            : Trace sampling terminates
frame no. = -00120 to  00050 : Frame -120 to 50 store data
step no.  = -00091 to  00022 : Step -91 to 22 store data
 >
```

- In Multi trace

```
 >SHOW MULTITRACE/STATUS
en/dis      = enable        : Multi trace function enabled
buffer full = nobreak       : Buffer full break function disabled
sampling    = end           : Trace sampling terminates
block no. = 1 to 5          : Block 1 to 5 store data
frame no. = 00001 to 00159  : Frame 1 to 159 store data
                              (Global number)
```

2.2.8.6 Specify Displaying Trace Data Start

It is possible to specify from which data in the trace buffer to display. To do so, specify a frame number with the SHOW TRACE command in the single trace mode, or specify either a global number, or a block number and local number with the SHOW MULTITRACE command in the multi trace mode. A range can also be specified.

■ Specifying Displaying Trace Data Start

It is possible to specify from which data in the trace buffer to displays. To do this, specify a frame number with the SHOW TRACE command in the single trace, and specify either a global number, or a block number and local number with the SHOW MULTITRACE command in the multi trace. A range can also be specified.

[Example]

- In Single Trace Mode

```
>SHOW TRACE/CYCLE -6        : Start displaying from frame -6
>SHOW TRACE/CYCLE -6..10    : Display from frame -6 to frame 10
>SHOW TRACE -6              : Start displaying from step -6
>SHOW TRACE -6..10          : Displays from step -6 to step 10
```

Note:

A step number can only be specified when the MCU execution mode is set to the debugging mode.

- In Multi trace

```
>SHOW MULTITRACE/GLOBAL 500      : Start displaying from frame 500 (Global number)
>SHOW MULTITRACE/LOCAL 2         : Displaying block number 2
>SHOW MULTITRACE/LOCAL 2,-5..5   : Display from frame -5 to frame 5 of block number 2
```

2.2.8.7 Display Format of Trace Data

A display format can be chosen by specifying a command identifier with the SHOW TRACE command in the single trace, and with the SHOW MULTITRACE command in the multi trace. The source line is also displayed if "Add source line" is selected using the SET SOURCE command.

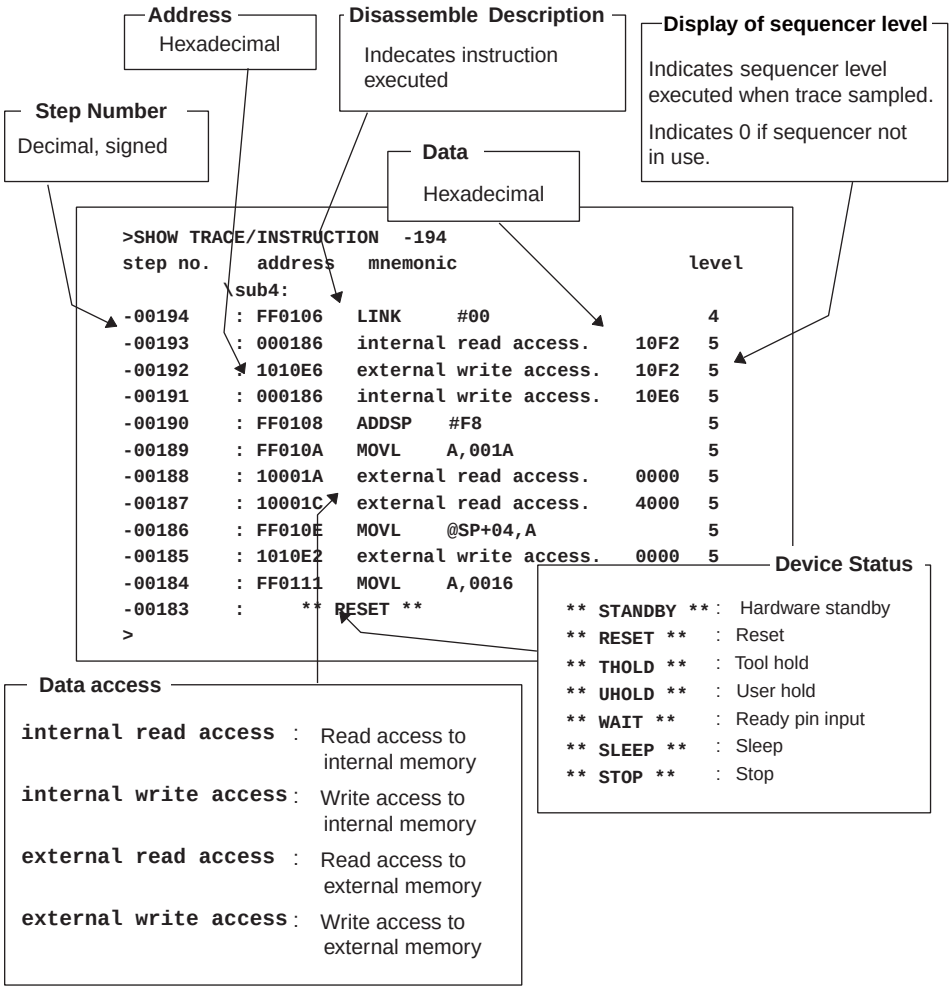
There are three formats to display trace data:

- **Display in instruction execution order (Specify /INSTRUCTION.)**
- **Display all machine cycles (Specify /CYCLE.)**
- **Display in source line units (Specify /SOURCE.)**

■ Display in Instruction Execution Order (Specify /INSTRUCTION.)

Trace sampling is performed at each machine cycle, but the sampling results are difficult to Display because they are influenced by pre-fetch, etc. This is why the emulator has a function to allow it to analyze trace data as much as possible. The resultant data is displayed after processes such as eliminating pre-fetch effects, analyzing execution instructions, and sorting in instruction execution order are performed automatically. However, this function can be specified only in the single trace while in the debugging mode.

In this mode, data can be displayed in the following format.



■ Displaying All Machine Cycles (Specify /CYCLE.)

Detailed information at all sampled machine cycles can be displayed. In this mode, both single trace and multi trace data can be displayed in almost identical formats. (In the multi trace mode, the local frame number and block number are added.)

In this mode, data can be displayed in the following format. For further details, see the descriptions of the SHOW TRACE, and SHOW MULTITRACE commands. In this mode, source is not displayed regardless of the setup made using the SET SOURCE command.

[Example]

```
 >>SHOW TRACE/CYCLE -587
frame no. address   data   a-status  d-status  Qst   dfg   level   ext-probe
-00587    :FF0106   0106   ---       -------   FLH          4      11111111
-00586    :FF0106   0008   ECF       EXECUTE   ---   @      4      11111111
-00585    :FF0106   0106   ---       EXECUTE   ---          5      11111111
-00584    :1010E8   10E8   ---       -------   ---          5      11111111
-00583    :1010E8   0102   EWA       EXECUTE   --    @      5      11111111
-00582    :1010E8   0102   ---       EXECUTE   ---          5      11111111
-00581    :000186   0186   ---       -------   2by         5      11111111
-00580    :000186   10F2   IRA       EXECUTE   ---   @      5      11111111
-00579    :1010E6   10E6   ---       -------   ---          5      11111111
-00578    :1010E6   10F2   EWA       EXECUTE   ---   @      5      11111111
-00577    :1010E6   10F2   ---       EXECUTE   ---          5      11111111
-00576    :000186   0186   ---       -------   ---          5      11111111
```

How to read trace data

frame no.	address	data	a-status	d-status	Qst	dfg	level	ext-probe
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

(1):frame number (Decimal, number)

(2):executed instruction address, and data access address (Hexadecimal number)

(3):data (Hexadecimal number)

(4):access information (a-status)

WA	:	write access to internal memory
EWA	:	write access to external memory
RA	:	read access to internal memory
ERA	:	read access to external memory
ICF	:	code fetch to internal memory
ECF	:	code fetch to external memory
---	:	valid "d-status" information

(5):device information (d-status)

STANDBY	:	hardware standby
THOLD	:	tool hold
UHOLD	:	user hold
WAIT	:	waiting with ready pin
SLEEP	:	sleep
STOP	:	stop
EXECUTE	:	execute instruction
RESET	:	reset
-------	:	invalid d-status information

(6):instruction queue status

FLH:flush queue

-by:number of remainder code of queue is -byte(-:1 to 8)

(7):valid flag

@:valid frame for this data

(8):sequencer level

(9):external probe data

■ Display in Source Line Units (Specify /SOURCE.)

Only the source line can be displayed. This mode is enabled only in the single trace mode while in the debugging mode.

[Example]

```
 >>SHOW TRACE/SOURCE -194
step no.   source
-00194 :   gtg1.c$251 {
-00190 :   gtg1.c$255       sub5(nf, nd);
-00168 :   gtg1.c$259 {
-00164 :   gtg1.c$264       p = (char *)  &df;
-00161 :   gtg1.c$264       p = (char *)  &df;
-00157 :   gtg1.c$265       *(p++) = 0x00;
-00145 :   gtg1.c$266       *(p++) = 0x00;
-00133 :   gtg1.c$267       *(p++) = 0x80;
-00121 :   gtg1.c$268       *p     = 0x7f;
-00116 :   gtg1.c$270       p = (char *)  &dd;
-00111 :   gtg1.c$271       *(p++) = 0xff;
-00099 :   gtg1.c$272       *(p++) = 0xff;
```

2.2.8.8 Reading Trace Data On-the-fly

Trace data can be read while executing a program. However, this is not possible during sampling. Disable the trace function or terminate tracing before attempting to read trace data.

■ Reading Trace Data On-the-fly in Single Trace

To disable the trace function, use the DISABLE TRACE command. Check whether or not the trace function is currently enabled by executing the SHOW TRACE command with /STATUS specified, or by using the built-in variable, %TRCSTAT.

Tracing terminates when the delay count ends after the sequencer has terminated. If Not Break is specified here, tracing terminates without a break operation. It is possible to check whether or not tracing has terminated by executing the SHOW TRACE command with /STATUS specified, or by using the built-in variable, %TRCSAMP.

To read trace data, use the SHOW TRACE command; to search trace data, use the SEARCH TRACE command. Use the SET DELAY command to set the delay count and break operation after the delay count.

[Example]

```
 >GO
 >>SHOW TRACE/STATUS
en/dis       = enable
buffer full  = nobreak
sampling     = on            <- Trace sampling continues.
 >>SHOW TRACE/STATUS
en/dis       = enable
buffer ful   = nobreak
sampling     = end           <- Trace sampling ends.
frame no.    = -00805 to  00000
step no.     = -00262 to  00000
 >>SHOW TRACE -52
step no.  address    mnemonic                              level
\sub5:
-00052    : FF0125   LINK   #02                            1
-00051    : 000186   internal read access.    10E6         1
-00050    : 1010D6   external write access.   10E6         1
-00049    : 000186   internal write access.   10D6         1
.         .          .
```

If the CLEAR TRACE command is executed with the trace ending state, trace data sampling can be re-executed by re-executing the sequencer from the beginning.

■ Reading Trace Data On-the-fly in the Multi Trace

Use the DISABLE MULTITRACE command to disable the trace function before reading trace data. Check whether or not the trace function is currently enabled by executing the SHOW MULTITRACE command with /STATUS specified, or by using the built-in variable %TRCSTAT.

To read trace data, use the SHOW MULTITRACE command; to search trace data, use the SEARCH MULTITRACE command.

[Example]

```
 >GO
>>SHOW MULTITRACE/STATUS
en/dis       = enable
buffer full  = nobreak
sampling     = on
 >>DISABLE MULTITRACE
 >>SHOW MULTITRACE/STATUS
en/dis       = disable
buffer full  = nobreak
sampling     = end
block no.    = 1 to 20
frame no.    = 00001 to 00639
 >>SHOW MULTITRACE  1
frame no.  address      data   a-status   d-status   Qst   dfg   level  ext-probe
block no. = 1
00001      -7 : 10109C  109C   ---        -------    ---         1      11111111
00002      -6 : 10109C  0000   EWA        EXECUTE    2by   @     1      11111111
00003      -5 : 10109C  0000   ---        EXECUTE    ---         1      11111111
00004      -4 : FF0120  0120   ---        -------    ---         1      11111111
                  .                        .                     .
                  .                        .                     .
```

2.2.8.9 Saving Trace Data

This section explains how to save trace data.

■ Saving Trace Data

Trace data can be saved in a specified file.

The following two methods are available to save trace data: using GUI (window or dialog) and using only the command. The same result is obtained from both methods.

● Using GUI for Saving Trace Data

1. Display the trace window.
   - Select [View] - [Trace] menu.
2. Specify the name of the file in which to save trace data.
   - Right-click on the trace window, and select [Save] from the shortcut menu. The [Save as] dialog appears.
     Specify the file name and where to save trace data. For details, refer to Section "4.4.8 Trace" in "SOFTUNE Workbench Operation Manual".

● Using Command for Saving Trace Data

1. Save trace data.
   - Execute the SHOW TRACE/FILE command.
     For details, refer to Section "4.33 SHOW TRACE (type 3)" in "SOFTUNE Workbench Command Reference Manual".
     When additionally saving trace data in an existing file, execute the SHOW TRACE/FILE/APPEND command.

2.2.9 Measuring Performance

It is possible to measure the time and pass count between two events. Repetitive measurement can be performed while executing a program in real-time, and when done, the data can be totaled and displayed.
Using this function enables the performance of a program to be measured. To measure performance, set the event mode to the performance mode using the SET MODE command.

■ Performance Measurement Function

The performance measurement function allows the time between two event occurrences to be measured and the number of event occurrences to be counted. Up to 32767 event occurrences can be measured.

- Measuring Time

Measures time interval between two events.

Events can be set at 8 points (1 to 8). However, in the performance measurement mode, the intervals, starting event number and ending event number are combined as follows. Four intervals have the following fixed event number combination:

Interval	Starting Event Number	Ending Event Number
1	1	2
2	3	4
3	5	6
4	7	8

- Measuring Count

The specified events become performance measurement points automatically, and occurrences of that particular event are counted.

2.2.9.1 Performance Measurement Procedures

Performance can be measured by the following procedure:

- **Setting event mode.**
- **Setting minimum measurement unit for timer.**
- **Specify performance-buffer-full break.**
- **Setting events.**
- **Execute program.**
- **Display measurement result.**
- **Clear measurement result.**

■ Setting Event Mode

Set the event mode to the performance mode using the SET MODE command. This enables the performance measurement function.

[Example]

```
>SET MODE/PERFORMANCE
>
```

■ Setting Minimum Measurement Unit for Timer

Using the SET TIMESCALE command, choose either 1 μs or 100 ns as the minimum measurement unit for the timer used to measure performance. The default is 1 μs.

When the minimum measurement unit is changed, the performance measurement values are cleared.

[Example]

```
>SET TIMERSCALE/1U           <- Set 1 μs as minimum unit.
>
```

■ Specify Performance-Buffer-Full Break

When the buffer for storing performance measurement data becomes full, a executing program can be broken. This function is called the performance-buffer-full break. The performance buffer becomes full when an event occurs 32767 times.

If the performance-buffer-full break is not specified, the performance measurement ends, but the program does not break.

[Example]

```
>SET PERFORMANCE/NOBREAK      <- Specifying Not Break
>
```

■ Setting Events

Set events using the SET EVENT command.

The starting/ending point of time measurement and points to measure pass count are specified by events.

Events at 8 points (1 to 8) can be set. However, in the performance measurement, the intervals, starting event number and ending event number are fixed in the following combination.

- Measuring Time

Four intervals have the following fixed event number combination.

Interval	Starting Event Number	Ending Event Number
1	1	2
2	3	4
3	5	6
4	7	8

- Measuring Count

The specified events become performance measurement points automatically.

■ Executing Program

Start measuring when executing a program by using the GO or CALL command. If a break occurs during interval time measurement, the data for this specific interval is discarded.

■ Displaying Performance Measurement Data

Display performance measurement data by using the SHOW PERFORMANCE command.

■ Clearing Performance Measurement Data

Clear performance measurement data by using the CLEAR PERFORMANCE command.

[Example]

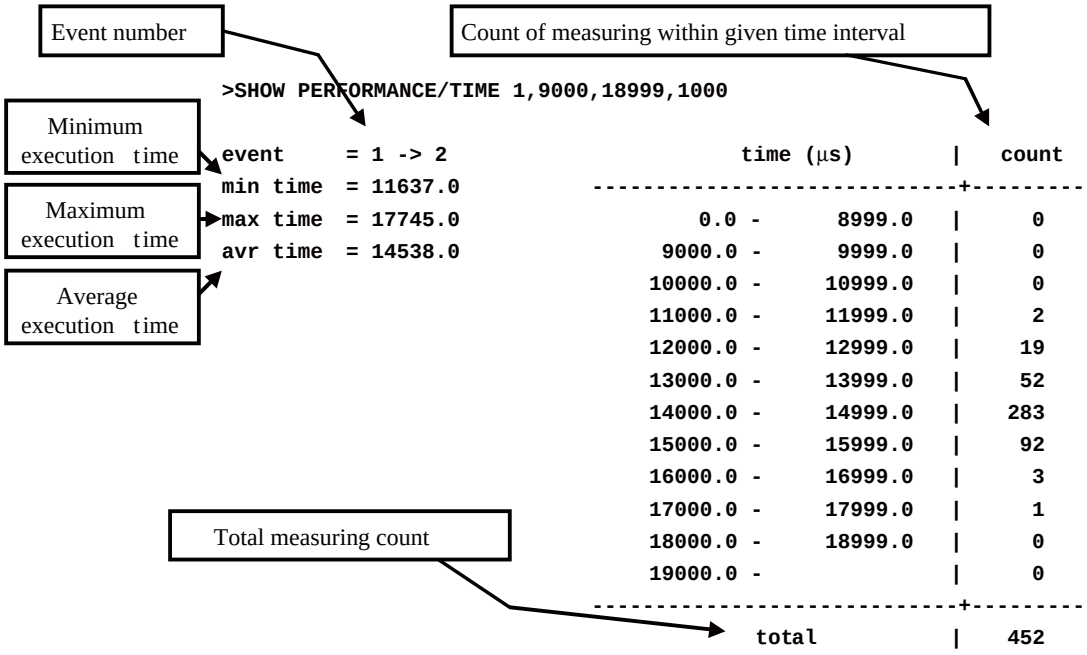
```
>CLEAR PERFORMANCE
>
```

2.2.9.2 Display Performance Measurement Data

Display the measured time and measuring count by using the SHOW PERFORMANCE command.

■ Displaying Measured Time

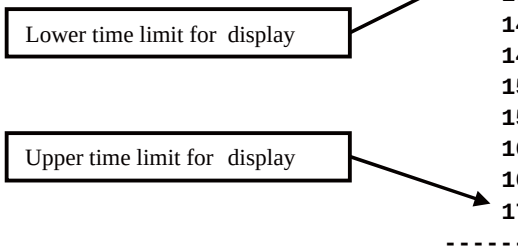
To display the time measured, specify the starting event number or the ending event number.




```
>SHOW PERFORMANCE/TIME 1,9000,18999,1000
event     = 1 -> 2
min time  = 11637.0
max time  = 17745.0
avr time  = 14538.0

                time (μs)          |   count
-------------------------------+---------
        0.0 -      8999.0      |      0
     9000.0 -      9999.0      |      0
    10000.0 -     10999.0      |      0
    11000.0 -     11999.0      |      2
    12000.0 -     12999.0      |     19
    13000.0 -     13999.0      |     52
    14000.0 -     14999.0      |    283
    15000.0 -     15999.0      |     92
    16000.0 -     16999.0      |      3
    17000.0 -     17999.0      |      1
    18000.0 -     18999.0      |      0
    19000.0 -                  |      0
-------------------------------+---------
          total                |    452
```

The lower time limit, upper time limit and display interval can be specified. The specified time value is in 1μs, when the minimum measurement unit timer is set to 1 μs by the SET TIMESCALE command, and in 100 ns when the minimum is set to 100 ns.




```
>SHOW PERFORMANCE/TIME  1,13000,16999,500
event    = 1 -> 2
min time = 11637.0
max time = 17745.0
avr time = 14538.0

                time (μs)          |   count
-------------------------------+---------
    13000.0 -     13499.0      |      13
    13500.0 -     13999.0      |      39
    14000.0 -     14499.0      |     121
    14500.0 -     14999.0      |     162
    15000.0 -     15499.0      |      76
    15500.0 -     15999.0      |      16
    16000.0 -     16499.0      |       2
    16500.0 -     16999.0      |       1
    17000.0 -     17499.0      |       1
-------------------------------+---------
          total                |     452
```

2.2.10 Measuring Coverage

This emulator has the C0 coverage measurement function. Use this function to find what percentage of an entire program has been executed.

■ Coverage Measurement Function

When testing a program, the program is executed with various test data input and the results are checked for correctness. When the test is finished, every part of the entire program should have been executed. If any part has not been executed, there is a possibility that the test is insufficient.

This emulator coverage function is used to find what percentage of the whole program has been executed. In addition, details such as which addresses were not accessed can be checked.

This enables the measurement coverage range to be set and the access attributes to be measured.

To execute the C0 coverage, set a range within the code area and set the attribute to Code attribute. In addition, specifying the Read/Write attribute and setting a range in the data area, permits checking the access status of variables such as finding unused variables, etc.

Execution of coverage measurement is limited to the address space specified as the debug area.

Therefore, set the debug area in advance. However, the measurement attribute for coverage measurement can be specified regardless of attributes of the debug area.

■ Coverage Measurement Procedures

The procedure for coverage measurement is as follows:

- Set range for coverage measurement: SET COVERAGE
- Measuring coverage: GO, STEP, CALL
- Displaying measurement result: SHOW COVERAGE

■ Coverage Measurement Operation

The following operation can be made in coverage measurement:

- Load/Save of coverage data: LOAD/COVERAGE, SAVE/COVERAGE
- Abortion and resume of coverage measurement: ENABLE COVERAGE, DISABLE COVERAGE
- Clearing coverage data: CLEAR COVERAGE
- Canceling coverage measurement range: CANCEL COVERAGE

Note:

With MB2141 emulator, the code coverage is affected by a prefetch by the MCU. Note the prefetch when using the COVERAGE function.

2.2.10.1 Coverage Measurement Procedures

The procedure for coverage measurement is as follows:

- **Set range for coverage measurement : SET COVERAGE**
- **Measure coverage : GO, STEP, CALL**
- **Display measurement result : SHOW COVERAGE**

■ Setting Range for Coverage Measurement

Use the SET COVERAGE command to set the measurement range. The measurement range can be set only within the area defined as the debug area. Up to 32 ranges can be specified.

In addition, the access attribute for measurement can be specified. This attribute can be specified regardless of the attributes of the debug area.

By specifying /AUTOMATIC for the command qualifier, the code area for the loaded module is set automatically. However, the library code area is not set when the C compiler library is linked.

[Example]

```
>SET COVERAGE FF0000 .. FFFFFF
```

■ Measuring Coverage

When preparing for coverage measurement, execute the program.

Measurement starts when the program is executed by using the GO, STEP, or CALL command.

■ Displaying Coverage Measurement Result

To display the coverage measurement result, use the SHOW COVERAGE command. The following can be displayed:

- Display coverage rate of total measurement area
- Displaying coverage rate of load module
- Summary of 16 addresses as one block
- Details indicating access status of each address
- Displaying coverage measurement result per source line
- Displaying coverage measurement result per machine instruction

● Displaying coverage rate of total measurement area (specify /TOTAL for the command qualifier)

```
>SHOW COVERAGE/TOTAL
```

total coverage : 82.3%

- Displaying coverage rate of load module (specify /MODULE for the command qualifier)

```
>SHOW COVERAGE/MODULE
sample.abs  . . . . . . . . . . . . . (84.03%)
 +- startup.asm . . . . . . . . . . . (90.43%)
 +- sample.c  . . . . . . . . . . . . (95.17%)
 +- samp.c  . . . . . . . . . . . . .  (100.00%)
```

Displays the load modules and the coverage rate of each module.

- Summary (Specify /GENERAL for command qualifier)

```
>SHOW COVERAGE/GENERAL
  (HEX)0X0            +1X0            +2X0
        +---------------+---------------+------         ------
address 0123456789ABCDEF0123456789ABCDEF0123456    ... ABCDEF   C0(%)
FF0000  **3*F*......                                        32.0
```

Display the access status of every 16 addresses
- . : No access
- 1 to F : Display the number accessed in 16 addresses by the hexadecimal number.
- * : Access all of the 16 addresses.

- Details (Specify /DETAIL for command qualifier)

Display one line of a coverage rate

```
>SHOW COVERAGE/DETAIL FF0000

address +0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +A +B +C +D +E +F C0(%)
FF0000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  100.0
FF0010   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  100.0
FF0020   .  .  .  .  -  -  -  .  .  .  .  .  .  .  .  .   18.6
FF0030   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  100.0
FF0040   -  .  -  -  -  -  -  -  -  -  -  -  -  -  -  -   93.7
FF0050   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  100.0
FF0060   .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .    0.0
FF0070   .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .    0.0
FF0080   .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .    0.0
```

Display the access status of every 1 address
- . : No access
- - : Access

- Displays per source line (specify /SOURCE for the command qualifier)

```
>SHOW COVERAGE/SOURCE main
*     70: {
      71:       int     i;
      72:       struct table *value[16];
      73:
*     74:       for (i=0; i<16; i++)
*     75:             value[i] = &target[i];
      76:
*     77:       sort_val(value, 16L);
.     78: }
```

Displays execution status of each source line.

. :	No executing
* :	Executing
Blank :	Line which the code had not been generated or is outside the scope of the coverage measurement

- Displays per machine instruction (specify /INSTRUCTION for the command qualifier)

```
>SHOW COVERAGE/INSTRUCTION F9028F
sample.c$70 {
 *  F9028F                  \main:
 *  F9028F 0822                 LINK    #22
 *  F90291 4F01                 PUSHW   RW0
sample.c$74       for (i=0; i<16; i++)
 .  F90293 D0                   MOVN    A,#0
 .  F90294 CBFE                 MOVW    @RW3-02,A
 .  F90296 BBFE                 MOVW    A,@RW3-02
 .  F90298 3B1000               CMPW    A,#0010
 .  F9029B FB18                 BGE     F902B5
sample.c$75           value[i] = &target[i];
 .  F9029D BBFE                 MOVW    A,@RW3-02
 .  F9029F 0C                   LSLW    A
 .  F902A0 98                   MOVW    RW0,A
 .  F902A1 71F3DE               MOVEA   A,@RW3-22
 .  F902A4 7700                 ADDW    RW0,A
 .  F902A6 4214                 MOV     A,#14
 .  F902A8 7833FE               MULUW   A,@RW3-02
 .  F902AB 38A001               ADDW    A,#01A0
```

Displays execution status of each machine command line.

. :	No executing
* :	Executing
Blank :	Instruction outside the scope of the coverage measurement

---

Note:

With MB2141 emulator, the code coverage measurement is affected by a prefetch. Note when analyzing.

2.2.11 Execution Time Measurement

This function measures the program execution time.

■ Measurement Items

Measures time between the start and stop of program execution.

The timer for measuring time is called the emulation timer.

The measurement time depends on as follows by the minimum measurement unit for the emulation timer.

When the minimum measurement unit is 1 μs: the maximum is about 70 minutes

When the minimum measurement unit is 100 ns: the maximum is about 7 minutes

The minimum measurement unit at startup is 1 μs.

The measurement is performed whenever a program is executed, and the measurement result displays the following two values:

- Number of cycles spent on the previous program execution
- Total number of cycles executed since the previous clearing

■ Setting the Minimum Measurement Unit

Either of the following methods can be used to set the minimum measurement unit for the emulation timer.

- Set by dialog

  Select [Setup] - [Debug Environment] - [Debug Environment] menu to set the results in [emulation] tab in the debugging environment set dialog.

  For details, refer to Section "4.7.2.3 Setting Debug Environment" in "SOFTUNE Workbench Operation Manual".

- Set by command

  Enter the SET TIMERSCALE command in the command window.

  For details, refer to Section "1.13 SET TIMERSCALE" in "SOFTUNE Workbench Command Reference Manual".

■ Displaying Measurement Results

Either of the following methods can be used to display the measurement results.

- Display by dialog

  The results appear in the time measurement dialog, which can be displayed by selecting [Debug] - [Time Measurement] menu.

  For details, refer to Section "4.6.8 Time Measurement" in "SOFTUNE Workbench Operation Manual".

- Display by command

  Enter the SHOW TIMER command in the command window.

  For details, refer to Section "4.27 SHOW TIMER" in "SOFTUNE Workbench Command Reference Manual".

■ Clearing Measurement Results

Either of the following methods can be used to clear the measurement results.

- Clearing by dialog

  Click the [Clear] button in the time measurement dialog, which can be displayed by selecting [Debug] - [Time Measurement] menu.

  For details, refer to Section "4.6.8 Time Measurement" in "SOFTUNE Workbench Operation Manual".

- Clearing by command

  Enter the CLEAR TIMER command in the command window.

  For details, refer to Section "4.28 CLEAR TIMER" in "SOFTUNE Workbench Command Reference Manual".

Note:

The measured execution time is added about ten extra cycles per execution. If the execution cycle is measured, execute many instructions continuously in order to minimize the effect of error.

2.2.12 Sampling by External Probe

An external probe can be used to sample (input) data. There are two sampling types: sampling the trace buffer as trace data, and sampling using the SHOW SAMPLING command.

■ Sampling by External Probe

There are two sampling types to sample data using an external probe: sampling the trace buffer as trace data, and sampling using the SHOW SAMPLING command.

When data is sampled as trace data, such data can be displayed by using the SHOW TRACE command or SHOW MULTITRACE command, just as with other trace data. Sampling using the SHOW SAMPLING command, samples data and displays its state.

In addition, by specifying external probe data as events, such events can be used for aborting a program, and as multi trace and performance trigger points.

Events can be set by using the SET EVENT command.

■ External Probe Sampling Timing

Choose one of the following for the sampling timing while executing a program.

- At rising edge of internal clock (clock supplied by emulator)
- At rising edge of external clock (clock input from target)
- At falling edge of external clock (clock input from target)

Use the SET SAMPLING command to set up; to display the setup status use the SHOW SAMPLING command.

When sampling data using the SHOW SAMPLING command, sampling is performed when the command is executed and has nothing to do with the above settings.

[Example]

```
>>SET SAMPLING/INTERNAL
>>SHOW SAMPLING
sampling timing : internal
channel           7 6 5 4 3 2 1 0
                  1 1 1 1 0 1 1 1
```

■ Displaying and Setting External Probe Data

When a command that can use external probe data is executed, external probe data is displayed in 8-digit binary or 2-digit hexadecimal format. The displayed bit order is in the order of the IC clip cable color code order (Table 2.2-12). The MSB is at bit7 (Violet), and the LSB is at bit0 (Black). The bit represented by 1 means HIGH, while the bit represented by 0 means LOW. When data is input as command parameters, these values are also used for input.

Table 2.2-12 Bit Order of External Probe Data

IC Clip Cable Color	Violet	Blue	Green	Yellow	Orange	Red	Brown	Black
Bit Order	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	External probe data							

■ Commands for External Probe Data

Table 2.2-13 shows the commands that can be used to set or display external probe data.

Table 2.2-13 Commands that can be used External Probe Data

Usable Command	Function
SET SAMPLING SHOW SAMPLING	Sets sampling timing for external probe Samples external probe data
SET EVENT SHOW EVENT	Enables to specify external probe data as condition for event Displays event setup status
SHOW TRACE	Displays external probe trace-sampled (single trace)
SHOW MULTITRACE	Displays external probe trace-sampled (multi-trace)

2.2.13 Checking Debugger Information

This section explains how to check information about the MB2141 emulator debugger.

■ Debugger Information

This emulator debugger enables you to check the following information at startup.

- SOFTUNE Workbench file information
- Hardware information

If any errors have been discovered during SOFTUNE Workbench operations, check this information and contact our sales department or support department.

■ How to Check

Use one of the following methods to check debugger information.

- Command
  - SHOW SYSTEM
    Refer to Section "1.19 SHOW SYSTEM" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Version information dialog
    Select [Help] - [Version Information] menu.
    For details, refer to Section "4.9.3 Version Information" in "SOFTUNE Workbench Operation Manual".

■ Displayed Contents

```
F2MC-16 Family SOFTUNE Workbench VxxLxx
ALL RIGHTS RESERVED,
  COPYRIGHT(C) FUJITSU SEMICONDUCTOR LIMITED 1997
LICENCED MATERIAL -
  PROGRAM PROPERTY OF FUJITSU SEMICONDUCTOR LIMITED
=======================================================
Cpu information file path: CPU information file path
Cpu information file version: CPU information file version
=======================================================
Add in DLLs
-------------------------------------------------------
 SiCmn
 Product name: SOFTUNE Workbench
 File Path: SiC907.dll path
 Version: SiC907.dll version
- - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 SiiEd
 File Path: SiiEd3.ocx path
 Version: SiiEd3.ocx version
-------------------------------------------------------
 SiM907
 Product name: SOFTUNE Workbench
 File Path: SiM907.dll path
 Version: SiM907.dll version
```

```
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Language Tools
 - F2MC-16 Family SOFTUNE C Compiler version
   File Path: fcc907s.exe path
 - F2MC-16 Family SOFTUNE Assembler version
   File Path: fasm907s.exe path
 - F2MC-16 Family SOFTUNE Linker version
   File Path: flnk907s.exe path
 - F2MC-16 Family SOFTUNE Librarian version
   File Path: flib907s.exe path
 - SOFTUNE FJ-OMF to S-FORMAT Converter version
   File Path: f2ms.exe path
 - SOFTUNE FJ-OMF to INTEL-HEX Converter version
   File Path: f2is.exe path
 - SOFTUNE FJ-OMF to INTEL-EXT-HEX Converter version
   File Path: f2es.exe path
 - SOFTUNE FJ-OMF to HEX Converter version
   File Path: f2hs.exe path
-----------------------------------------------------
 SiOsM
 Product name: Softune Workbench
 File Path: SiOsM907.dll path
 Version: SiOsM907.dll version
-----------------------------------------------------
 F2MC-16 Series Debugger DLL
 Product name: SOFTUNE Workbench
 File Path: SiD907.dll path
 Version: SiD907.dll version
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Debugger type         : Current debugger type
MCU type              : Currently selected target MCU
VCpu dll name         : Path and name of the currently used VCpu dll
VCpu dll version      : Version of the currently used virtual debugger DLL
DSU type              : Currently used DSU type
Monitor version       : Version of monitor (dependent)
Communication device  : Device type
Baud rate             : Baud rate
Host name             : LAN host name
REALOS version        : REALOS version
-----------------------------------------------------
 SiIODef
 Product name: Softune Workbench
 File Path: SiIODef.dll path
 Version: SiIODef.dll version
=====================================================
Current path: Path of the currently used project
Language: Currently used language
Help file path: Help file path
```

2.3 Emulator Debugger (MB2147-01)

This section explains the functions of the emulator debuggers for the MB2147-01.

■ Emulator

When choosing the emulator debugger from the setup wizard, select one of the following emulators. The following description explains the case when MB2147-01 has been selected.

MB2141
MB2147-01
MB2147-05
MB2198

The emulator debugger for the MB2147-01 is software that controls an emulator from a host computer via a communications line (RS-232C, LAN or USB) to evaluate programs.

The following series can be debugged:

F^2MC-16L
F^2MC-16LX

Before using the emulator, the emulator must be initialized. For details, refer to "Appendix B Monitoring Program Download" and "Appendix C LAN Interface Setup" of "SOFTUNE Workbench Operation Manual".

2.3.1 Setting Operating Environment

This section explains the operating environment setup.

■ Setting Operating Environment

For the emulator debugger for the MB2147-01, it is necessary to set the following operating environment. Predefined default settings for all these setup items are enabled at startup. Therefore, setup is not required when using the default settings. Adjusted settings can be used as new default settings from the next time.

- Monitoring program automatic loading
- MCU operation mode
- Debug area
- Memory mapping
- Debug function
- Event mode

2.3.1.1 Monitoring Program Automatic Loading

The MB2147-01 emulator can automatically update the monitoring program at emulator startup.

■ Setting Monitoring Program Automatic Loading

When the MB2147-01 emulator is specified, data in the emulator can be checked at the beginning of debugging to load an appropriate monitoring program and configuration binary data automatically into the emulator.

The monitoring program and configuration binary data to be compared for update are in Lib\907 under the directory where Workbench is installed.

Enable/disable the monitoring program automatic loading function by choosing [Environment] - [Debug Environment Setup] - [Setup Wizard] menu.

2.3.1.2 MCU Operation Mode

There are two MCU operation modes as follows:

- **Debugging Mode**
- **Native Mode**

■ Setting MCU Operation Mode

Set the MCU operation mode.

There are two operation modes: the debugging mode, and the native mode.

Choose either one using the SET RUNMODE command.

At emulator start-up, the MCU is in the debugging mode.

The data access to internal bus may not be detected by emulator in native mode. Therefore, when the MCU operation mode is changed, all the following are initialized:

- Data breakpoints
- Data monitoring break
- Event condition settings
- Sequencer settings
- Trace measurement settings and trace buffer

■ Debugging Mode

All the operations of evaluation chips can be analyzed, but their operating speed is slower than that of mass-produced chips.

■ Native Mode

Evaluation chips have the same timing as mass-produced chips to control the operating speed. Note that the restrictions the shown in Table 2.3-1 are imposed on the debug functions.

Table 2.3-1 Restrictions on Debug Functions in Native Mode

Applicable series	Restrictions on debug functions
Common to all series	- When a data read access occurs on the MCU internal bus, the internal bus access information is not sampled and stored in the trace buffer. - Even when a data break or event (data access condition) is set for data on the MCU internal bus, it may not become a break factor or sequencer-triggering factor. - The coverage function may fail to detect an access to data on the MCU internal bus.

2.3.1.3 Debug Area

Set the intensive debugging area out of the whole memory space. The area functions are enhanced.

■ Setting Debug Area

There are two debug areas: DEBUG3, and DEBUG4. A continuous 1 MB area (16 banks) is set for each area.

Set the debug area using the SET DEBUG command.

Setting the debug area enhances the coverage measurement function.

- Enhancement of Coverage Measurement Function

Setting the debug area enables the coverage measurement function. In coverage measurement, the measurement range can be specified only within the area specified as the debug area. In 00 to 0F bank and 0F0 to 0FF bank, a breakpoint can be set without specifying the debug area. (DEBUG1, DEBUG2)

2.3.1.4 Memory Area Types

A unit in which memory is allocated is called an area. There are five different area types.

■ Memory Area Types

A unit to allocate memory is allocated is called an area. There are five different area types as follows:

- User Memory Area

Memory space in the user system is called the user memory area and this memory is called the user memory. Up to four user memory areas can be set with no limit on the size of each area. Define a region on a 256-byte boundary.

Access attributes can be set for each area; for example, CODE, READ, etc., can be set for ROM area, and READ, WRITE, etc. can be set for RAM area. If the MCU attempts access in violation of these attributes, the MCU operation is suspended and an error is displayed (guarded access break).

Memory manipulation commands can be executed in relation to emulation memory areas while MCU execution is in progress.

To set the user memory area, use the SET MAP command.

- Emulation Memory Area

Memory space substituted for emulator memory is called the emulation memory area, and this memory is called emulation memory.

It is possible to set up to four areas of 1 MB maximum (including an internal ROM area described later) as emulation memory area. Define a region on a 256-byte boundary. An area larger than 1 MB can be specified at one time but is divided internally into two or more 1 MB areas for management purposes.

Memory manipulation commands can be executed in relation to emulation memory areas while MCU execution is in progress.

Emulation memory areas can be set using the SET MAP command.

Further, the access attributes can be set as with user memory areas.

Note:

Even if the MCU internal resources are set as emulation memory area, access is made to the internal resources. Re-executing this setup may damage data.

- Internal ROM Area

The area where the emulator internal memory is substituted for internal ROM is called the internal ROM area, and this memory is called the internal ROM memory.

The internal ROM area with a size up to 1 MB can be specified two areas.

An area larger than 1 MB can be specified at one time but is divided internally into two or more 1 MB areas for management purposes.

Memory manipulation commands can be executed in relation to emulation memory areas while MCU execution is in progress.

The internal ROM area is capable to set by the "Setup Map" dialog opening by "Debugger Memory Map" from "Setup".

Note:

The internal memory area, it is set a suitable area automatically by the selected MCU.

- Internal ROM Image Area

Some types of MCUs have data in a specific area of internal ROM appearing to 00 bank. This specific area is called the internal ROM image area.

The internal ROM image area is capable to set by the "Setup Map" dialog opening by "Debugger Memory Map" from "Setup". This area attribute is automatically set to READ/CODE. The same data as in the internal ROM area appears in the internal ROM image area.

Note that the debug information is only enabled for either one (one specified when linked). To debug only the internal ROM image area, change the creation type of the load module file.

Note:

The internal memory area, it is set a suitable area automatically by the selected MCU.

- Undefined Area

A memory area that does not belong to any of the areas described above is part of the user memory area. This area is specifically called the undefined area.

The undefined area can be set to either NOGUARD area, which can be accessed freely, or GUARD area, which cannot be accessed. Select either setup for the whole undefined area. If the area attribute is set to GUARD, a guarded access error occurs if access to this area is attempted.

2.3.1.5 Memory Mapping

Memory space can be allocated to the user memory and the emulation memory, etc., and the attributes of these areas can be specified.
However, the MCU internal resources are not dependent on this mapping setup and access is always made to the internal resources.

■ Access Attributes for Memory Areas

The access attributes shown in Table 2.3-2 can be specified for memory areas.

A guarded access break occurs if access is attempted in violation of these attributes while executing a program.

When access to the user memory area and the emulation memory area is made using program commands, such access is allowed regardless of the CODE, READ, WRITE attributes. However, access to memory with the GUARD attribute in the undefined area, causes an error.

Table 2.3-2 Types of Access Attributes

Area	Attribute	Description
User Memory Emulation Memory	CODE	Instruction Execution Enabled
	READ	Data Read Enabled
	WRITE	Data Write Enabled
Undefined	GUARD	Access Disabled
	NOGUARD	No check of access attribute

When access is made to an area without the WRITE attribute by executing a program, a guarded access break occurs after the data has been rewritten if the access target is the user memory. However, if the access target is the emulation memory, the break occurs before rewriting. In other words, write-protection (memory data cannot be overwritten by writing) can be set for the emulation memory area by not specifying the WRITE attribute for the area.

This write-protection is only enabled for access made by executing a program, and is not applicable to access by commands.

■ Creating and Viewing Memory Map

Use the following commands for memory mapping.

SET MAP: Set memory map.

SHOW MAP: Display memory map.

CANCEL MAP: Change memory map setting to undefined.

[Example]

```
 >SHOW MAP
address              attribute         type
000000 .. FFFFFF     noguard
The rest of setting area numbers
user = 8    emulation = 5
 >SET MAP/USER H'0..H'1FF
 >SET MAP/READ/CODE/EMULATION H'FF0000..H'FFFFFF
 >SET MAP/USER H'8000..H'8FFF
 >SET MAP/MIRROR/COPY H'8000..H'8FFF
 >SET MAP/GUARD
 >SHOW MAP
address              attribute         type
000000 .. 0001FF     read write        user
000200 .. 007FFF     guard
008000 .. 008FFF     read write        user
009000 .. FEFFFF     guard
FF0000 .. FFFFFF     read write code   emulation
mirror address area
008000 .. 008FFF     copy
The rest of setting area numbers
user = 6    emulation = 3
 >
```

■ Internal ROM Area Setting

The [Setup Map] dialog box is displayed using [Environment] - [Memory Map] menu. You can set the internal ROM area using the [Internal ROM Area] tab after the [Map Adding] dialog box is displayed by clicking on the [Setting] button. You can set two areas. Both require empty Emulation area to be set. You can set the region size by (Empty space of the emulation area) x (one area size).

Specify the internal ROM area from the ending address H'FFFFFF (fixed) for area 1. Also, it is possible to delete the internal ROM area.

2.3.1.6 Debug Function

The debug function has the following two types. Only the function of the selected mode can be used. The selectable debug mode depends on the emulator or its connection form.

- **RAM Checker mode**
- **Trace Enhancement mode**

■ Setting of Debug Function

Set the debug function. The debug function has the RAM Checker and the Trace Enhancement mode. The selectable mode depends on the emulator or its connection form. These modes can be set by using [Setup] - [Debug Environment] - [Select Debug Function] menu or the SET MODE command on the command window.

At the emulator activated, this is set to the RAM Checker mode.

When the debug function is changed, all the followings are initialized:

- Performance measurement data
- Trace buffer

■ RAM Checker mode

Enables the RAM Checker function. The history of accessing the monitoring addresses can be recorded into the log file.

■ Trace Enhancement mode

Enable the trace enhancement.

The following functions become available.

1. Trace acquisition in the multi trace mode
2. Trace acquisition control by trace trigger (resumption/pausing/termination)
3. Trace control by data monitoring condition
4. Trace control by sequencer

2.3.1.7 Event Mode

There are three event modes as listed below.

- **Normal mode**
- **Multi trace mode**
- **Performance mode**

■ Event Mode

Event mode is used to determine which function the event triggers are used for. To set the mode, use [Event] tab on [Setup] - [Debug Environment] - [Debug Environment] menu or the SET MODE command on the command window. The default is normal mode.

There are three event modes as listed below.

- Normal mode

  Event triggers are used for the single trace.
- Multi trace mode

  Event triggers are used for the multi trace (trace function which samples data before and after the event trigger occurred).
- Performance mode

  Event triggers are used for the performance measurement. It enables to measure time duration between two event trigger occurrence and count of event trigger occurrence.

Note:

The multi trace mode can be specified only when the debug function on MB2147-01 is set to Trace Enhancement mode. For more details, see Section "2.3.1.6 Debug Function".

2.3.2 Notes on Commands for Executing Program

When using commands to execute a program, there are several points to note.

■ Notes on GO Command

For the GO command, two breakpoints that are valid only while executing commands can be set. However, care is required in setting these breakpoints.

- Invalid Breakpoints

- No break occurs when a breakpoint is set at the instruction immediately after the following instructions.

F^2MC-16L/16LX	PCB NCC SPB MOV ILM,#imm8 OR CCR,#imm8	DTB ADB CNR ANDCCR,#imm8 POPW PS

- No break occurs when breakpoint set at address other than starting address of instruction.
- No break occurs when both following conditions met at one time.
  - Instruction for which breakpoint set starts from odd-address,
  - Preceding instruction longer than 2 bytes length, and breakpoint already set at last 1-byte address of preceding instruction (This "already-set" breakpoint is an invalid breakpoint that won't break, because it has been set at an address other than the starting address of an instruction).

- Abnormal Breakpoint

Setting a breakpoint at the instruction immediately after string instructions listed below, may cause a break in the middle of the string instruction without executing the instruction to the end.

F^2MC-16L/16LX	MOVS SECQ WBTS MOVSWI SECQWI MOVSD SECQD FILS FILSW	MOVSW SECQW MOVSI SECQI WBTC MOVSWD SECQWD FILSI FILSWI

■ Notes on STEP Command

- Exceptional Step Execution

When executing the instructions listed in the notes on the GO command as invalid breakpoints and abnormal breakpoints, such instructions and the next instruction are executed as a single instruction. Furthermore, if such instructions are continuous, then all these continuous instructions and the next instruction are executed as a single instruction.

- Step Execution that won't Break

Note that no break occurs after step operation when both the following conditions are met at one time.

- When step instruction longer than 2 bytes and last code ends at even address
- When breakpoint already set at last address (This "already-set" breakpoint is an invalid breakpoint that won't break, because it has been set at an address other than the starting address of an instruction.)

■ Controlling Watchdog Timer

It is possible to select "No reset generated by watchdog timer counter overflow" while executing a program using the GO, STEP, CALL commands.

Use the ENABLE WATCHDOG, DISABLE WATCHDOG commands to control the watchdog timer.

- ENABLE WATCHDOG : Reset generated by watchdog timer counter overflow
- DISABLE WATCHDOG : No reset generated by watchdog timer counter overflow

The start-up default in this program is "Reset generated by watchdog timer counter overflow".

[Example]

```
>DISABLE WATCHDOG
>GO
```

2.3.3 Commands Available during Execution of User Program

This section explains the commands available during the execution of a user program.

■ Commands Available during Execution of User Program

This emulator debugger allows you to use certain commands during the execution of a user program.

For more details, see "■ Debugger" in "SOFTUNE Workbench Command Reference Manual".

The double circle indicates that it is available during the execution of a user program.

Table 2.3-3 shows the commands available during the execution of a user program.

Table 2.3-3 Commands Available during Execution of User Program (1 / 2)

Function	Restrictions	Major Commands
MCU reset	-	1.3 RESET
Displaying trace data	1. Enabled only when trace execution ended *1 2. Enabled only when the debug function is in "Trace Enhancement" mode.*2 (only MULTITRACE)	4.2 SHOW MULTITRACE, 4.31 SHOW TRACE(type 1)
Clear trace data	1. Enabled only when trace execution ended *1 2. Enabled only when the debug function is in "Trace Enhancement" mode.*2 (only MULTITRACE)	4.3 CLEAR MULTITRACE, 4.34 CLEAR TRACE
Search trace data	1. Enabled only when trace execution ended *1 2. Enabled only when the debug function is in "Trace Enhancement" mode.*2 (only MULTITRACE)	4.6 SEARCH MULTITRACE, 4.37 SEARCH TRACE
Set trace acquisition data	Enabled only when trace execution ended *1	4.35 ENABLE TRACE, 4.36 DISABLE TRACE
Set trace trigger	1. Enabled only when trace execution ended *1 2. Enabled only when the debug function is in "Trace Enhancement" mode.*2	4.42 SET TRACETRIGGER, 4.43 SHOW TRACETRIGGER, 4.44 CANCEL TRACETRIGGER
Set filtering area	1. Enabled only when trace execution ended *1 2. Enabled only when the debug function is in "Trace Enhancement" mode.*2	4.38 SET DATATRACEAREA, 4.40 SHOW DATATRACEAREA, 4.41 CANCEL DATATRACEAREA

Table 2.3-3 Commands Available during Execution of User Program (2 / 2)

Function	Restrictions	Major Commands
Set trace delay	1. Enabled only when trace execution ended *1 2. Enabled only when the debug function is in "Trace Enhancement" mode.*2	4.45 SET DELAY, 4.46 SHOW DELAY
Displaying execution cycle measurement value (Timer)	-	4.27 SHOW TIMER
Memory operation (Read/Write)	Emulation memory only operable *3 Read only enabled in real-time monitoring area	5.1 EXAMINE, 5.2 ENTER, 5.3 SET MEMORY, 5.4 SHOW MEMORY, 5.5 SEARCH MEMORY, 5.8 COMPARE, 5.9 FILL, 5.10 MOVE, 5.11 DUMP
Line assembly, Disassembly	Emulation memory only enabled *3 Real-time monitoring area, Disassembly only enabled	6.1 ASSEMBLE 6.2 DISASSEMBLE
Breakpoint Settings	Oprable only when "Breakpoint Settings during Execution" is enabled in the execution tab of the debug environment dialog.	3.1 SET BREAK, 3.6 CANCEL BREAK, 3.7 ENABLE BREAK, 3.8 DISABLE BREAK, 3.9 SET DATABREAK, 3.12 CANCEL DATABREAK, 3.13 ENABLE DATABREAK, 3.14 DISABLE DATABREAK

*1: For detail, refer to Section "2.3.6 Real-time Trace".

*2: For detail, refer to Section "2.3.1.6 Debug Function".

*3: For detail, refer to Section "2.2.1.4 Memory Mapping".

*4: For detail, refer to Section "2.3.4 Break".

Notes:

- The conditions which allow you to use the commands in Table 2.3-3 are limited to the following cases when a user program is executed.
  - [Debug] - [Run] - [Go] menu
  - [Go] button on the debug toolbar

  The commands in Table 2.3-3 cannot be used when the GO command is entered in the command window.
- An error message appears if you enter a command that cannot be used during the execution of a user program.

  "E4404S Command error (MCU is busy)."

2.3.4 Break

In this emulator debugger, nine types of break functions can be used. When the program execution is aborted by each break function, the address and the break factor to do the break are displayed.

■ Break Functions

In this emulator debugger, nine types of break functions are supported.

- Code break
- Data break
- Monitoring data break
- Sequential break
- Guarded access break
- Trace-buffer-full break
- Performance-buffer-full break
- External trigger break
- Forced break

2.3.4.1 Code Break

It is a function to abort the program by observing the specified address. The break is done before an instruction the specified address is executed.

■ Code Break

It is a function to abort the program by observing the specified address. The break is done before an instruction the specified address is executed. It is possible to set it in this 65535 debuggers.

When a break occurs due to a code break, the following message is displayed on the Status Bar.

Break at Address by breakpoint

■ Setting Method

The code break is controlled by the following method.

- Command
  - SET BREAK
    Refer to "3.1 SET BREAK (type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Breakpoints set dialog [Code] tab
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".
- Window
  - Source window/Disassembly window

■ Notes on Data Break

There are several points to note in using code break. First, some points affecting code break are explained.

● Invalid Breakpoints

- No break occurs when a breakpoint is set at the instruction immediately after the following instructions.

  F^2MC-16/16L/16LX/16H: • PCB • DTB • NCC • ADB • SPB • CNR
  • MOV ILM,#imm8 • AND CCR,#imm8
  • OR CCR,#imm8 • POPW PS

  F^2MC-16F: • PCB • DTB • NCC • ADB • SPB • CNR
- No break occurs when breakpoint set at address other than starting address of instruction.
- No break occurs when both following conditions met at one time.
  - Instruction for which breakpoint set starts from odd-address
  - Preceding instruction longer than 2 bytes length, and breakpoint already set at last 1-byte address of preceding instruction (This "already-set" breakpoint is an invalid breakpoint that won't break, because it has been set at an address other than the starting address of an instruction.)

● Abnormal Breakpoint

- Setting a breakpoint at the instruction immediately after string instructions listed below, may cause a break in the middle of the string instruction without executing the instruction to the end.

F^2MC-16/16L/16LX/16H:	• MOVS	• MOVSW	• SECQ	• SECQW	• WBTS
	• MOVSI	• MOVSWI	• SECQI	• SECQWI	• WBTC
	• MOVSD	• MOVSWD	• SECQD	• SECQWD	
	• FILS	• FILSI	• FILSW	• FILSWI	
F^2MC-16F: Above plus	• MOVM	• MOVMW			

Here are some additional points about the effects on other commands.

● Dangerous Breakpoints

- Never set a breakpoint at an address other than the instruction starting address. If a breakpoint is the last 1 byte of an instruction longer than 2 bytes length, and if such an address is even, the following abnormal operation will result:
  - If instruction executed by STEP command, instruction execution not aborted.
  - If breakpoint specified with GO command, set at instruction immediately after such instruction, the breakpoint does not break.

Note:

When the debugging area is set again, all breakpoints in the area are cleared.

2.3.4.2 Data Break

The data break is a function to abort the program execution when the data access (read or write) is done to the address specified while executing the program.

■ Data Break

The data break is a function to abort the program execution when MCU accesses data as for a specified address. It is possible to set it in this two debuggers.

When a break occurs due to a data break, the following message is displayed on the Status Bar.

Break at Address by databreak at Access address

■ Setting Method

The data break is controlled by the following method.

- Command
  - SET DATABREAK
    Refer to "3.9 SET DATABREAK (type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Breakpoints set dialog [Data] tab
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".

Note:

When the debugging area is set again, all breakpoints in the area are cleared.

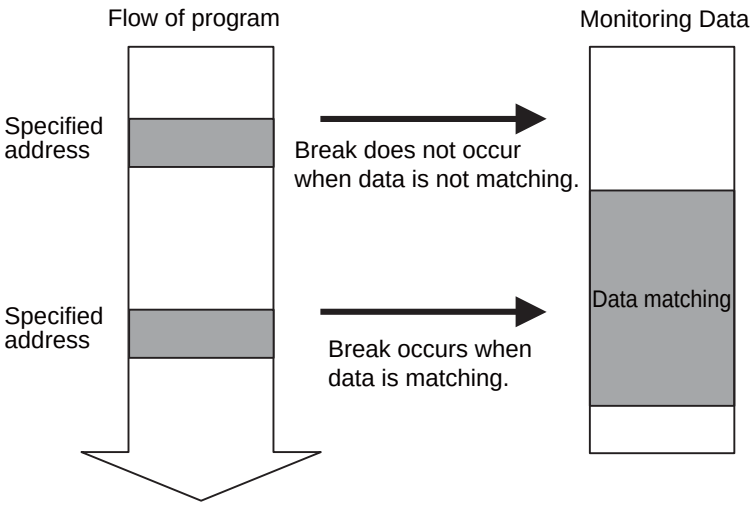
2.3.4.3 Monitoring Data Break

It is a special break function to abort execution while it is corresponding to specified data when the program reaches a specified address.

■ Monitoring Data Break

It is a special break function to abort execution while it is corresponding to specified data when the program reaches a specified address.

If the break condition of the data watch break is shown in figure, it becomes as shown in the figure below.



■ Setting Number

The maximum constant and break conditions of monitoring data break vary as follows:

- Monitoring Data Break

  Break conditions are set by address and data. Up to four points can be set. However, the break conditions vary due to combination use with the "Sequencer" or the "Trace trigger".

■ Setting Method

The data monitoring break can be set depending on the following command.

- Command
  - SET BREAK/DATAWATCH
- Dialog
  - Breakpoints set dialog [code] tab

    "Hardware/Monitoring data"

2.3.4.4 Sequential Break

A sequential break is a function to abort a executing program, when the sequential condition is met by event sequential control.

■ Sequential Break

It is a function to discontinue the program execution when the sequential condition consists by the sequential control of the event. Use a sequential break when the event mode is set to normal mode using the SET MODE command.

When a break occurs due to a sequential break, the following message is displayed on the Status Bar.

Break at Address by sequential break

For details of the sequential break function, refer to Section "2.3.5 Control by Sequencer".

■ Setting Method

The sequential break is controlled by the following method.

1. Set event mode (SET MODE)
2. Set events (SET EVENT)
3. Set sequencer (SET SEQUENCE)

2.3.4.5 Guarded Access Break

The guarded access break is an abortion of the program execution that happens when the violation to the set access attribute, doing the access, and guarded (An undefined area cannot be accessed) area are accessed.

■ Guarded Access Break

A guarded access break aborts a executing program when access is made in violation of the access attribute set by using the [Setup] - [Memory Map] menu, and access is attempted to a guarded area (access-disabled area in undefined area).

There are three types of the following in Guarded access break.

Code guarded

When the instruction execution is done to the area without the code attribute, the break is done.

Read guarded

When the area without the read attribute is read, the break is done.

Write guarded

When the area without the write attribute is write, the break is done.

If a guarded access occurs while executing a program, the following message is displayed on the Status Bar and the program is aborted.

Break at Address by guarded access {code/read/write} at Access address

Note:

Code Guarded is affected by pre-fetching.

The F^{2}MC-16L/16LX/16/16H family pre-fetch up to 4 bytes. So, when setting the program area mapping, set a little larger area (5 bytes max.) than the program area actually used.

Similarly, the F^{2}MC-16F family pre-fetch up to 8 bytes. So, when setting the program area mapping, set a little larger area (9 bytes max.) than the program area actually used.

2.3.4.6 Trace-Buffer-Full Break

It is a function to abort the program execution when the trace buffer becomes full.

■ Trace-Buffer-Full Break

It is a function to abort the program execution when the trace buffer becomes full.

When a break occurs due to a trace-buffer-full break, the following message is displayed on the Status Bar.

Break at Address by trace buffer full

■ Setting Method

The trace-buffer-full break is controlled by the following method.

- Command
  - SET TRACE/BREAK
    Refer to "4.30 SET TRACE (type 2)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Trace Set Dialog
    Refer to "4.4.8 Trace" in "SOFTUNE Workbench Operation Manual".

2.3.4.7 Performance-Buffer-Full Break

It is a function to abort the program execution when the buffer for the performance measurement data storage becomes full.

■ Performance-Buffer-Full Break

It is a function to abort the program execution when the buffer for the performance measurement data storage becomes full.

When a break occurs due to a performance-buffer-full break, the following message is displayed on the Status Bar.

Break at Address by performance buffer full

■ Setting Method

The performance-buffer-full break is controlled by the following method.

- Command
  - SET PERFORMANCE/BREAK
    Refer to "4.7 SET PERFORMANCE (type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Performance set dialog
    Refer to "4.4.13 Performance" in "SOFTUNE Workbench Operation Manual".

2.3.4.8 External Trigger Break

It is a function to abort the execution of the program when an external signal is input from TRIG pin that the emulator has.

■ External Trigger Break

It is a function to abort the execution of the program when an external signal is input from TRIG pin that the emulator has.

When a break occurs due to an external trigger break, the following message is displayed on the Status Bar.

Break at Address by external trigger break

■ Setting Method

The external trigger break is controlled by the following method.

- Command
  - SET TRIGGER
    Refer to "3.42 SET TRIGGER" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Debugging environment set dialog [emulation] tab
    Refer to "4.7.2.3 Debug Environment" in "SOFTUNE Workbench Operation Manual".

2.3.4.9 Forced Break

It is a function to abort the execution of the program compulsorily.

■ Forced Break

It is a function to abort the execution of the program compulsorily.

When a break occurs due to a forced break, the following message is displayed on the Status Bar.

Break at Address by command abort request

Note:

A forced break is not allowed while the MCU is in the low-power consumption mode or hold state. When a forced break is requested by the [Debug] - [Abort] menu while executing a program, the menu is disregarded if the MCU is in the low-power consumption mode or hold state. If a break must occur, then reset the cause at user system side, or reset the cause by using the [Debug] - [Reset MCU] menu, after inputting the [Debug] - [Abort] menu.

When the MCU enters the power-save consumption mode or hold state while executing, the status is displayed on the Status Bar.

2.3.5 Control by Sequencer

This emulator has a sequencer to control events. By using this sequencer, sampling of breaks or traces can be controlled while monitoring program flow (sequence). A break caused by this function is called a sequential break.

■ Control by Sequencer

As shown in Table 2.3-4, controls can be made at 3 different levels.

One event can be set for one level.

The sequencer always moves from Level 1 through Level 2 to Level 3. One event can be specified as a sequencer restart condition.

When the debug function on MB2147-01 is set to Trace Enhancement mode, it is possible to control a trace by a sequencer.

1. Complete the trace acquisition.
2. Transit to the next block (Only in multi trace mode)

Table 2.3-4 Sequencer Specifications

Function	Specifications
Level count	3 levels+ restart condition
Conditions settable for each level	1 event conditions (1 to 16777215 times pass count can be specified for each condition.)
Restart conditions	1 event conditions (1 to 16777215 times pass count can be specified.)
Operation when conditions established	Branching to another level or terminating sequencer

■ Setting Events

The emulator can monitor the MCU bus operation, and generate a trigger for a sequencer at a specified condition. This function is called an event.

In the event, code (/CODE) and data access (/READ/WRITE) can be specified.

Up to eight events can be set. However, since hardware is shared with trace triggers, the actual numbers is calculated as follows.

Current maximum constant of events
= 8 - (current number of trace trigger settings + current number of data monitoring break settings)

Table 2.3-5 shows the conditions that can be set for events.

Table 2.3-5 Conditions for Event and Trace Trigger

Condition	Description
Address	Memory location (address bit masking disabled)
Data	16-bit data (data bit masking enabled)
Access size	Byte, word
Status	Select from code, data read or data write

Note:

In instruction execution (/CODE), an event trigger is generated only when an instruction is executed. This cannot be specified concurrently with other status (/READ or /WRITE).

Use the following commands to set an event.

SET EVENT : Sets an event
SHOW EVENT : Displays the status of event setting
CANCEL EVENT : Deletes an event

[Example]

```
>SET EVENT/CODE  func1
>SET EVENT/WRITE data[2],!d=h'10
>SET EVENT/READ/WRITE 102
```

2.3.5.1 Setting Sequencer

The sequencer operates in the following order:
1) The sequencer starts after the program execution.
2) Depending on the setting at each level (1 & 2), branching to the next level is performed when the condition is met.
3) The sequencer is restarted when the restart condition is met.
4) The sequencer is terminated and a break occurs when the level 3 condition is met.

■ Setting Sequencer

The sequencer operates in the following order: The event can be set at each level and as a restart condition.

1. The sequencer starts after the program execution.
2. Depending on the setting at each level (1 & 2), branching to the next level is performed when the condition is met.
3. The sequencer is restarted when the restart condition is met.
4. The sequencer is terminated and a break occurs when the level 3 condition is met.

Use the following commands to set the sequencer.

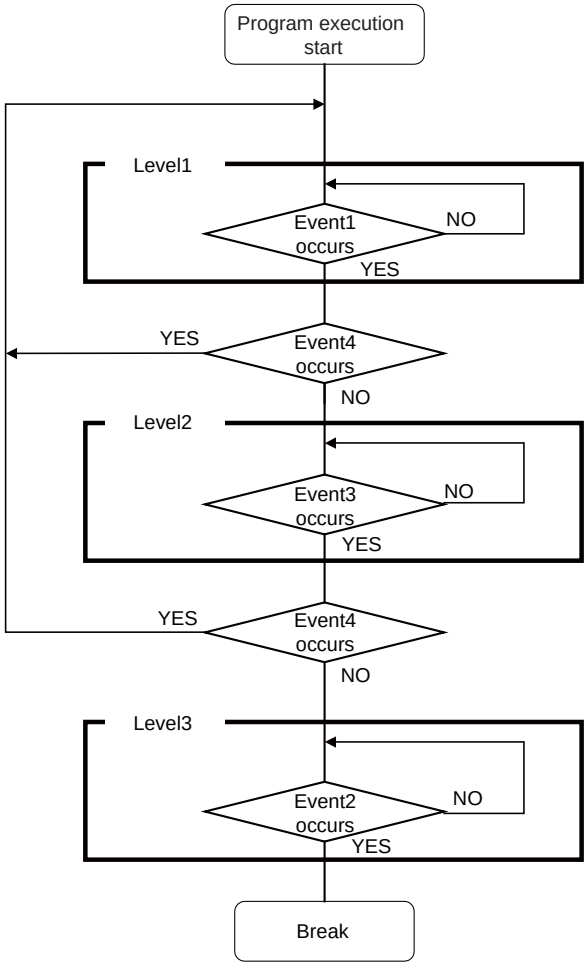
SET SEQUENCE: Setting an event for the sequencer

[Example]

```
>SET SEQUENCE 1, 3, 2, r=4
```

Set event 1, 3, 2 to level 1, 2, 3 respectively, and event 4 for the restart condition.

Figure 2.3-1 Operation of Sequencer



■ Setting Sequencer

The sequencer can be set by the dialog or the command.

- Setting by dialog

  Select [Debug] - [Sequence] menu.

  For details, refer to "4.6.6 Sequence" in "SOFTUNE Workbench Operation Manual".

- Setting by Command

  1. The event is set according to the SET EVENT command.
  2. The event set by the SET SEQUENCE command is set as a sequence.
     For details, refer to "3.22 SET EVENT (type 2)" or "3.28 SET SEQUENCE (type2)" in "SOFTUNE Workbench Command Reference Manual".

2.3.6 Real-time Trace

While execution a program, the address, data and status information, and the data sampled by an external probe can be sampled in machine cycle units and stored in the trace buffer. This function is called real-time trace.
In-depth analysis of a program execution history can be performed using the data recorded by real-time trace.

■ Trace Buffer

The data recorded by sampling in machine cycle units, is called a frame.

The trace buffer can store 64K frames (65536). Since the trace buffer has a ring structure, when it becomes full, it automatically returns to the start to overwrite existing data.

■ Trace Data

Data sampled by the trace function is called trace data.

The following data is sampled:

- Address
- Data
- Status Information
  - Access status: Read/Write/Internal access, etc.
  - Device status: Instruction execution, Reset, Hold, etc.
  - Queue status: Count of remaining bytes of instruction queue, etc.
  - Data valid cycle information: Data valid/invalid
    (Since the data signal is shared with other signals, it does not always output data. Therefore, the trace samples information indicating whether or not the data is valid.)
- Execution time based on the previous trace frame (in 25-ns units)

■ Data Not Traced

The following data does not leave access data in the trace buffer.

- Portion of access data while in native mode.

When operating in the native mode, the F^2MC-16L/16LX family of chips sometime performs simultaneous multiple bus operations internally. However, in this emulator, monitoring of the internal ROM bus takes precedence. Therefore, other bus data being accessed simultaneously may not be sampled (in the debugging mode, all operations are sampled).

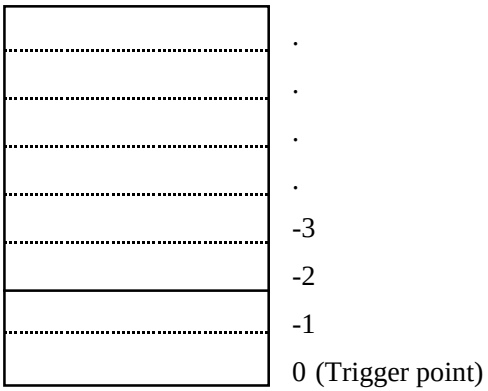
■ Frame number

A number is assigned to each frame of sampled trace data. This number is called a frame number.

The frame number is used to specify the display start position of the trace buffer. The value 0 is assigned to trace data at the triggering position for sequencer termination. Negative values are assigned to trace data that have been sampled before arrival at the triggering position (See Figure 2.3-2).

If there is no triggering position for sequencer termination, the value 0 is assigned to the last-sampled trace data.

Figure 2.3-2 Frame Numbering at Tracing



■ Trace Filter

To make effective use of the limited trace buffer capacity, in addition to the code fetch function, a trace filter function is incorporated to provide a means of acquiring information about data accesses to a specific region.

The data trace filter function allows the following values to be specified for two regions:

- Address
- Address mask
- Access attribute (read/write)

Another function can be used so that sampling of redundant frames occupying two or more trace frames, such as SLEEP and READY, can be reduced to sampling of one frame.

■ Trace Trigger Setup

When preselected conditions are met during MCU bus operation monitoring, a trigger for starting a trace can be generated. This function is called a trace trigger.

For the use of the trace trigger function, specify the code (/CODE) and data access (/READ/WRITE).

Up to 8 trace triggers can be preset each for code attribute and data access attribute. However, actually, the maximum number of trace triggers is determined as indicated below because the common hardware is used with events.

Current trace trigger maximum constant
= 8 - (current data monitoring break count setting + current event count setting)

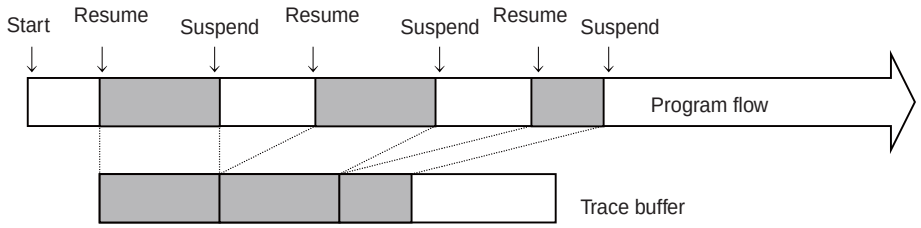
For the trace trigger setup conditions that can be defined, see Table 2.3-4.

For trace trigger setup, use the following commands:

- SET TRACETRIGGER : Sets trace trigger
- CANCEL TRACETRIGGER : Deletes trace trigger
- SHOW TRACE/STATUS : Displays trace setup status

Figure 2.3-3 shows a trace sampling operation.

Figure 2.3-3 Trace Sampling Operation (Trace Trigger)



■ Setting Data Monitoring Trace Trigger

When the debug function on MB2147-01 is set to Trace Enhancement mode, it is possible to set a trace trigger by a data monitoring condition.

For the data monitoring condition, see the data monitoring break in Section "2.3.4 Break".

Current maximum constant of data monitoring trace triggers
= 8 - (number of data monitoring break settings + number of trace trigger settings + current number of event settings)

Use the following commands to set the data monitoring trace trigger.

SET TRACETRIGGER/DATAWATCH :	Sets a data monitoring trace trigger
CANCEL TRACETRIGGER/DATAWATCH :	Deletes a data monitoring trace trigger
SHOW TRACETRIGGER/DATAWATCH :	Displays a data monitoring trace trigger

■ Trace Control during Executing User Program

In MB2147-01, the trace control is enabled while the user program is executed. However, it is necessary to end the trace execution.

The parameter that can be controlled is as follows;

- Set trace trigger
- Set filtering area
- Display trace data
- Clear trace data
- Search trace data
- Set trace delay*
- Display measurement result of time*
- Forced termination/resumption of trace execution*

*: Only when the debugging is in trace enhancement mode.

Notes:

- The trace execution means the trace data acquisition is "Tracing" or "Pause".
- The following method exists to terminate the trace execution.

1. Forced termination of trace execution
   - Trace window - Shortcut menu [Forced termination]
   - Trace toolbar [Forced termination] button
2. Trace trigger (Termination)
   - SET TRACETRIGGER command
   - Trace trigger setting dialog

2.3.6.1 Setting Single Trace

To perform a single trace, follow steps 1 through 4 below. When a program is executed after completion of the following steps, trace data is sampled.
1) Set an event mode to single trace mode.
2) Enable the trace function.
3) Perform the event and sequencer setup.
4) Perform trace buffer full break setup.

■ Setting Trace

To perform a single trace, complete the following setup steps. When a program is executed after completion of the steps, trace data is sampled.

1) Set an event mode to single trace mode.

Use SET MODE command for this setting.

2) Enable the trace functions.

Enable the trace function using the ENABLE TRACE command.

To disable the trace function, use the DISABLE TRACE command.

Note that the trace function is enabled by default when the program is launched.

3) Perform the event and sequencer setup.

Use of a trace trigger makes it possible to control trace sampling and make effective use of the limited trace buffer capacity. If there is no such necessity, setup need not be performed.

With a trace trigger, it is possible to specify the start and stop of trace sampling to be performed at a trigger hit.

To use a trace trigger, input the SET TRACE/TRIGGER command and then perform trace trigger setup using the SET TRACETRIGGER command.

4) Perform trace buffer full break setup.

A break can be invoked when the trace buffer becomes full.

To perform setup, use the SET TRACE command. This break feature is disabled when the program starts. To view the setting, use SHOW TRACE/STATUS.

Table 2.3-6 lists trace-related commands in the single trace.

Table 2.3-6 Trace-related Commands Available in Single Trace

Available command	Function
SET TRACETRIGGER CANCEL TRACETRIGGER	Sets trace trigger Deletes trace trigger
SET TRACE SHOW TRACE SEARCH TRACE ENABLE TRACE DISABLE TRACE CLEAR TRACE	Sets trace buffer full break Displays trace data Searches for trace data Enables trace function Disables trace function Clears trace function

2.3.6.2 Multi Trace

Only when an event trigger occurred, the multi trace samples data before and after the event trigger.

■ Multi Trace

To use the multi trace function, the SET MODE command is set to the following mode.

Debug function: "Trace Enhancement" mode

Event mode: "Multi trace" mode

The multi trace samples data where an event trigger (trace end trigger) occurs before and after the event trigger.

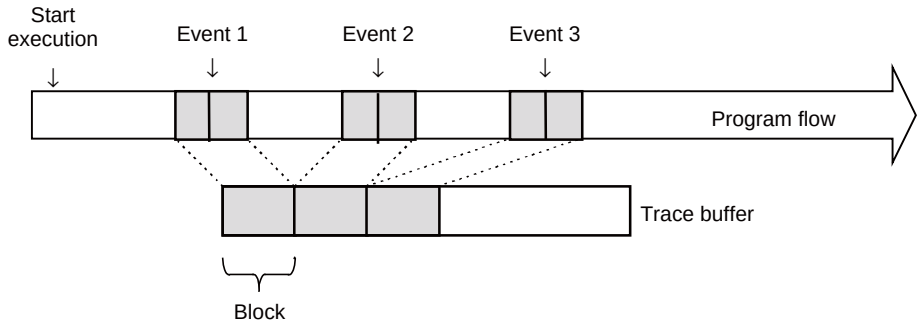
It can be used for tracing required only when a certain variable access occurs, instead of continuous tracing.

The trace data sampled at one event trigger is called a block. The trace buffer for multi trace in MB2147-01 can hold 64K frames. When dividing into blocks, select the size of one block from 128/256/512/1024 frame. 64 to 512 blocks can be sampled according to the block size.

There are the following two event triggers of the multi trace.

- Trace end trigger: Change to the next block in the point that becomes a hit.
- Multi trace end trigger: Terminate the trace acquisition in the point that becomes a hit.

Figure 2.3-4 Multi Trace Sampling



■ Multi Trace Frame Number

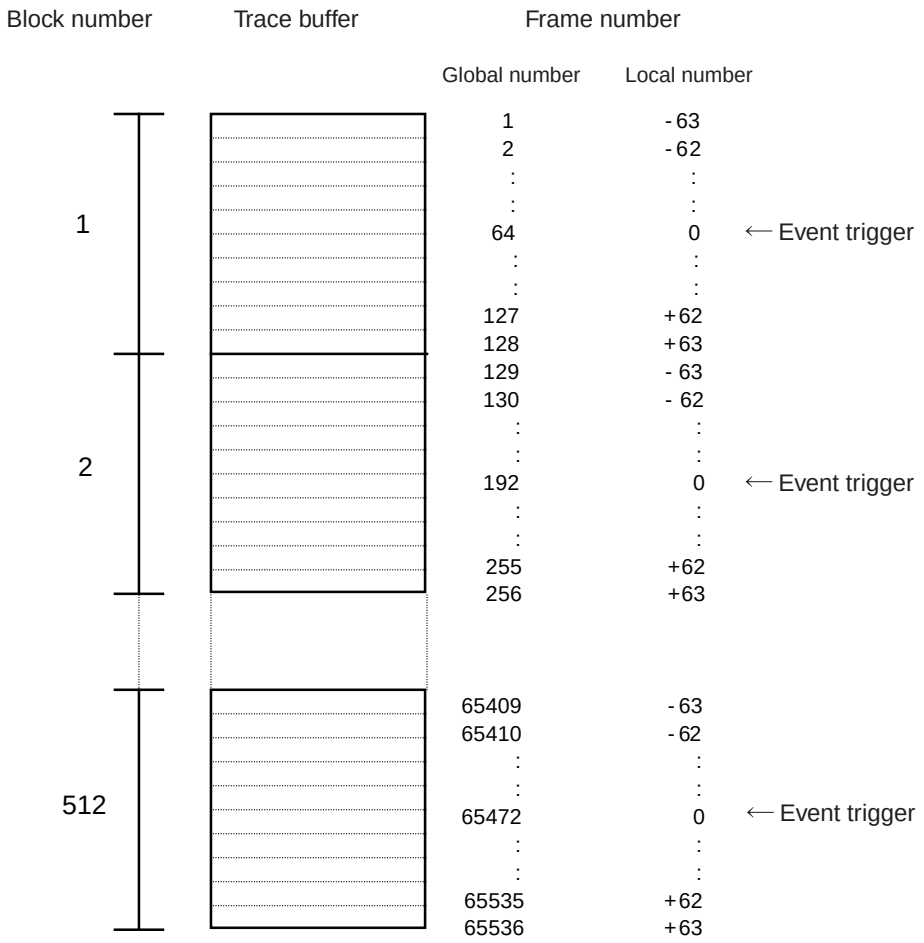
Data of 128 to 1024 frames can be sampled according to the block size at each time an event occurs (trace end trigger). This data unit is called a block, and each sampled block is numbered starting from 0. This is called the block number.

A block is a collection of sampled data before and after the event trigger occurs. At the event trigger is 0, trace data sampled before reaching the event trigger point is numbered negatively, and trace data sampled after the event trigger point is numbered positively. These frame numbers are called local numbers (See Figure 2.3-5).

In addition to this local number, there is another set of frame numbers starting 1 with the oldest data in the trace buffer. This is called the global number. Since the trace buffer can hold 64K frames, frames are numbered 1 to 65536 (See Figure 2.3-5).

To specify which frame data is displayed, use the global number or block and local numbers.

Figure 2.3-5 Frame Number in Multi Trace



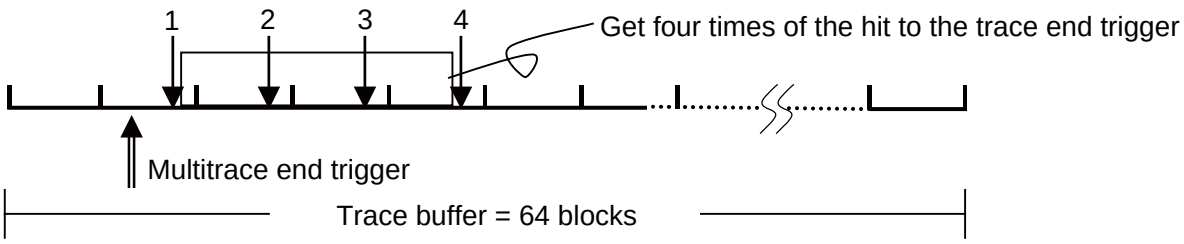
■ Trace Delay

The trace data which is acquired after one event occurrence is called a trace delay. There are two types of trace delay depending on the event hit.

When the trace end trigger (event) hit occurs, the delay can be set within the scope of the block size (128 to 1024 frames). A block is sampled data in combination with the trace data before the event hit and the trace delay.

When the multi trace end trigger (event) hit occurs, the delay is acquired as many as the number of occurrence of the subsequent trace end trigger hit.

Example: If you want to get the trace delay for three blocks, the event hit needs to occur four times.



Note:

The multi trace function in MB2147-01 is exclusive with the RAM Checker function. For more details, refer to Section "2.3.1.6 Debug Function".

2.3.6.3 Setting Methods of Multi Trace

Before executing the multi trace, the following settings must be made. After these settings, trace data is sampled when a program is executed.

1. Set the debug function to "Trace Enhancement" mode.
2. Set event mode to multi trace mode.
3. Enable trace function.
4. Set event and sequencer.
5. Set trace-buffer-full break.

■ Setting Methods of Multi Trace

Before executing the multi trace, the following settings must be made. After these settings, trace data is sampled when a program is executed.

1) Set the debug function to Trace Enhancement mode.

Use SET MODE command for this setting.

2) Set event mode to multi trace mode.

Use the SET MODE command for this setting.

3) Enable trace function.

Use the ENABLE MULTITRACE command for this setting. To disable the function, use the DISABLE MULTITRACE command.

4) Set an event (trace trigger).

Set an event for sampling the multi trace. Use the SET TRACETRIGGER command for this setting.

5) Set trace-buffer-full break.

To break when the trace buffer becomes full, set the trace-buffer-full break. Use the SET MULTITRACE command for this setting.

6) Set a block size.

Use SET MULTITRACE command to set this.

7) Set a trace delay.

Use SET DELAY command to set this.

Table 2.3-7 shows the list of trace-related commands that can be used in multi trace mode.

Table 2.3-7 Trace-related Commands That Can Be Used in Multi Trace Mode

Mode	Usable Command	Function
Multi trace mode	SET TRACETRIGGER SHOW TRACETRIGGER CANCEL TRACETRIGGER ENABLE TRACETRIGGER DISABLE TRACETRIGGER	Sets events Displays event setup status Deletes event Enables event Disables event
	SET MULTITRACE SHOW MULTITRACE SEARCH MULTITRACE ENABLE MULTITRACE DISABLE MULTITRACE CLEAR MULTITRACE	Sets trace-buffer-full break Displays trace data Searches trace data Enables trace function Disables trace function Clears trace data
	SET DELAY SHOW DELAY	Sets trace delay Displays trace delay

2.3.6.4 Displaying Trace Data Storage Status

It is possible to displays how much trace data is stored in the trace buffer. This status data can be read by specifying /STATUS to the SHOW TRACE command.

■ Displaying Trace Data Storage Status

It is possible to displays how much trace data is stored in the trace buffer. This status data can be read by specifying /STATUS to the SHOW TRACE.

[Example]

```
>SHOW TRACE/STATUS
en/dis      = enable           ;   Trace function enabled
buffer full = nobreak          ;   Buffer full break function disabled
sampling    = end              ;   Trace sampling terminates
code        = enable           ;   Code execution enabled
verbose     = disable          ;   Verbose trace disabled
frame no.   = -00120 to  00000 ;   Frame -120 to 0 store data
>
```

2.3.6.5 Specify Displaying Trace Data Storage Status

The data display start position in the trace buffer can be specified by inputting a step number or frame number using the SHOW TRACE command. The data display range can also be specified.

■ Specifying Displaying Trace Data Start

Specify the data display start position in the trace buffer by inputting a step number or frame number using the SHOW TRACE command. The data display range can also be specified.

[Example]

- In Single Trace Mode

```
>SHOW TRACE/CYCLE -6     ; Start displaying from frame -6
>SHOW TRACE/CYCLE -6..0  ; Display from frame -6 to frame 0
>SHOW TRACE -6           ; Start displaying from frame -6
>SHOW TRACE -6..0        ; Displays from frame -6 to frame 0
```

2.3.6.6 Display Format of Trace Data

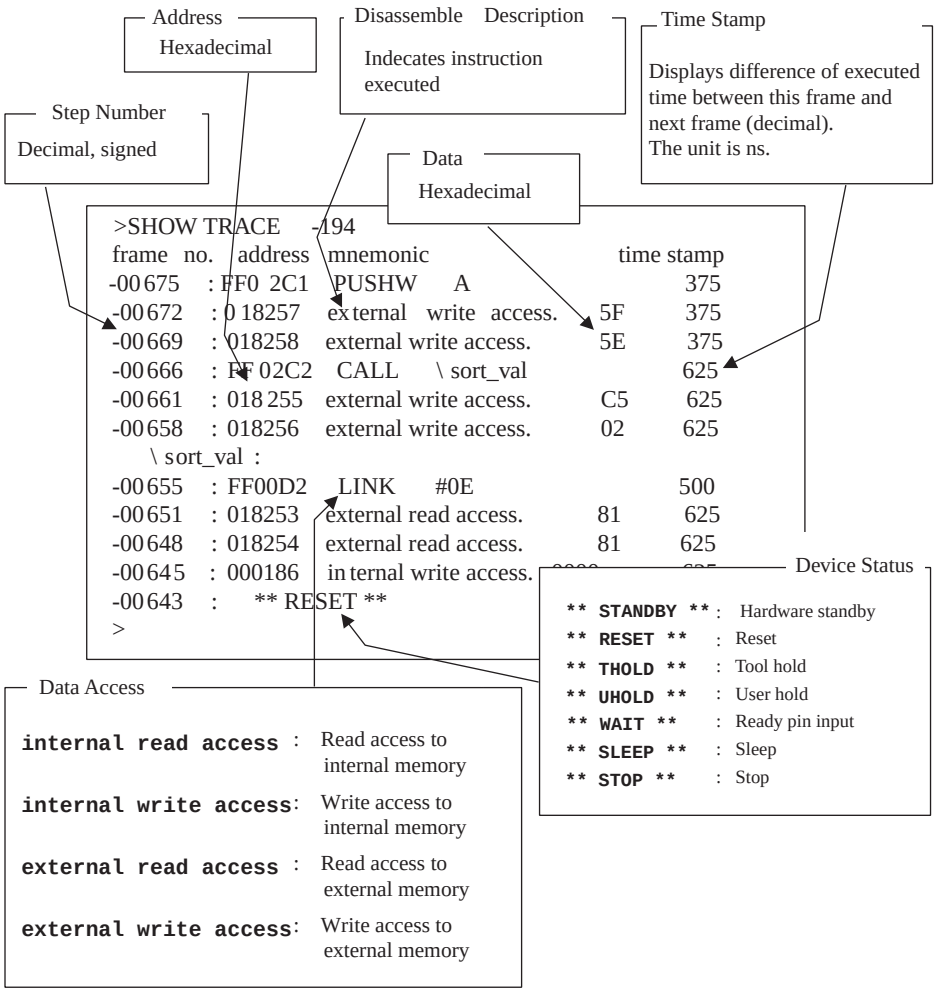
The trace data display format can be selected by running the SHOW TRACE command with a command modifier specified. If setup is completed with the SET SOURCE command so as to select a source line addition mode, a source line is attached to the displayed trace data.
There are three formats to display trace data:

- **Display in instruction execution order (Specify /INSTRUCTION.)**
- **Display all machine cycles (Specify /CYCLE.)**
- **Display in source line units (Specify /SOURCE.)**

■ Display in Instruction Execution Order (Specify /INSTRUCTION.)

Trace sampling is performed at each machine cycle, but the sampling results are difficult to display because they are influenced by pre-fetch, etc. This is why the emulator has a function to allow it to analyze trace data as much as possible. The resultant data is displayed after processes such as eliminating pre-fetch effects, analyzing execution instructions, and sorting in instruction execution order are performed automatically. However, this function can be specified only in the single trace while in the debugging mode.

In this mode, data can be displayed in the following format.



■ Displaying All Machine Cycles (Specify /CYCLE)

Detailed information at all sampled machine cycles can be displayed.

In this mode, no source is displayed irrespective of the setup defined by the SET SOURCE command.

[Example]

```
>SHOW TRACE/CYCLE -672
frame no. address   data  a-status  d-status  Qst  dfg event   time stamp
-00672    : 018257  ----  EWA       -------   ---  &                125
-00671    : 018257  5F    ---       EXECUTE   ---  @                125
-00670    : 018257  5F    ---       EXECUTE   ---  @                125
-00669    : 018257  ----  EWA       -------   ---  &                125
-00668    : 018257  82    ---       EXECUTE   ---  @                125
-00667    : FF02C6  5F    ---       EXECUTE   ---  @                125
-00666    : ------  ----  ---       EXECUTE   4by       C            125
-00665    : FF02C6  ----  ICF       -------   ---  &    D           125
-00664    : FF02C6  5F06  ---       EXECUTE   FLH  @                125
-00663    : FF00D2  ----  ICF       -------   ---  &                125
-00662    : FF00D2  0E08  ---       EXECUTE   ---  @                125
-00661    : 018255  ----  EWA       -------   ---  &                125
```

How to read trace data

frame no.	address	data	a-status	d-status	Qst	dfg	event	time stamp
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

(1):frame number (Decimal number)

(2):executed instruction address, and data access address (Hexadecimal number)

(3):data (Hexadecimal number)

(4):access information (a-status)

IWA	:	write access to internal memory
EWA	:	write access to external memory
IRA	:	read access to internal memory
ERA	:	read access to external memory
ICF	:	code fetch to internal memory
ECF	:	code fetch to external memory
---	:	valid "d-status" information

(5):device status (d-status)

STANDBY	:	hardware standby
THOLD	:	tool hold
UHOLD	:	user hold
WAIT	:	waiting with ready pin
SLEEP	:	sleep
STOP	:	stop
EXECUTE	:	execute instruction
RESET	:	reset
-------	:	invalid d-status information

(6):instruction queue status

FLH	:	flush queue
-by	:	number of remainder code of queue is - byte (-: 1 to 8)

(7):information valid flag

&	:	address is valid
@	:	data is valid

(8):event information

C	:	code event
D	:	data event

(9):time stamp display (ns unit)

displays difference of executed time between this frame and next frame (decimal)

Note:

Information about event hits is excluded from the displayed information. For code execution, in particular, the effect of a prefetch is eliminated in consideration of the count of data in the instruction queue. Therefore, the information about hits is displayed for frames after a prefetch frame at an address for which an event is set.

■ Display in Source Line Units (Specify /SOURCE.)

Only the source line can be displayed. This mode is enabled only in the debugging mode.

[Example]

```
>SHOW TRACE/SOURCE -1010..-86
step no. source
-01007   : sample.c$68        value[i] =  &target[I];
-00905   : sample.c$68        value[i] =  &target[I];
-00803   : sample.c$68        value[i] =  &target[I];
-00698   : sample.c$70     sort_val(value, 16L);
-00655   : sample.c$9  {
-00594   : sample.c$13     for (k = max / 2; k  >= 1; k--){
-00185   : sample.c$14                  i = k;
-00149   : sample.c$15        p = tblp[i - 1];
-00088   : sample.c$16        while ((j = 2 * i)  <= max){
```

Note:

The following operation may be subjected to trace sampling immediately after the MCU operation is stopped (tool hold). Remember that the operation is unique to evaluation chips and not performed by mass-produced products.

Access to address 0x000100 and addresses between 0x0FFFFDC and 0x0FFFFFF

2.3.6.7 Reading Trace Data On-the-fly

Trace data can be read while executing a program. However, this is not possible during sampling. Disable the trace function or terminate tracing before attempting to read trace data.

■ Reading Trace Data On-the-fly

To disable the trace function, use the DISABLE TRACE command. Check whether or not the trace function is currently enabled by executing the SHOW TRACE command with /STATUS specified, or by using the built-in variable, %TRCSTAT.

Tracing terminates when the delay count ends after the sequencer has terminated. If Not Break is specified here, tracing terminates without a break operation. It is possible to check whether or not tracing has terminated by executing the SHOW TRACE command with /STATUS specified, or by using the built-in variable, %TRCSAMP.

To read trace data, use the SHOW TRACE command; to search trace data, use the SEARCH TRACE command. Use the SET DELAY command to set the delay count and break operation after the delay count.

[Example]

```
>GO
>>SHOW TRACE/STATUS
en/dis      = enable
buffer ful  = nobreak
sampling    = on          <- Trace sampling continues.
code        : enable
verbose     : disable
>>SHOW TRACE/STATUS
en/dis      = enable
buffer full = nobreak
sampling    = end         <- Trace sampling ends.
code        : enable
verbose     : disable
frame no.   = -00805 to  00000
>>SHOW TRACE -52
step no.  address     mnemonic                    time stamp
sort_val:
-00655    : FF00D2    LINK          #0E                 625
-00651    : 018253    external  read access.        81    500
-00648    : 013254    external  read access.        81    625
-00645    : 000186    internal  write access.       0000  625
              .               .               .
```

If the CLEAR TRACE command is executed with the trace ending state, trace data sampling can be re-executed by re-executing the sequencer from the beginning.

2.3.6.8 Saving Trace Data

This section explains how to save trace data.

■ Saving Trace Data

Trace data can be saved in a specified file.

The following two methods are available to save trace data: using GUI (window or dialog) and using only the command. The same result is obtained from both methods.

● Using GUI for Saving Trace Data

1. Display the trace window.
   - Select [View] - [Trace] menu.
2. Specify the name of the file in which to save trace data.
   - Right-click on the trace window, and select [Save] from the shortcut menu. The [Save as] dialog appears.
     Specify the file name and where to save trace data. For details, refer to Section "4.4.8 Trace" in "SOFTUNE Workbench Operation Manual".

● Using Command for Saving Trace Data

1. Save trace data.
   - Execute the SHOW TRACE/FILE command.
     For details, refer to Section "4.33 SHOW TRACE (type 3)" in "SOFTUNE Workbench Command Reference Manual".
     When additionally saving trace data in an existing file, execute the SHOW TRACE/FILE/APPEND command.

2.3.7 Measuring Performance

It is possible to measure the time and pass count between two events. Repetitive measurement can be performed while executing a program in real-time, and when done, the data can be totaled and displayed.
Using this function enables the performance of a program to be measured. To measure performance, set the event mode to the performance mode using the SET MODE command.

■ Performance Measurement Function

The performance measurement allows the time between two event occurrences to be measured and the number of event occurrences to be counted. Up to 65535 event occurrences can be measured.

● Measuring Time

Measures time interval between two events.

Events can be set at 8 points (1 to 8). However, in the performance measurement mode, the intervals, starting event number and ending event number are combined as follows. Four intervals have the following fixed event number combination:

Interval	Starting Event Number	Ending Event Number
1	1	2
2	3	4
3	5	6
4	7	8

● Measuring Count

The specified events become performance measurement points automatically, and occurrences of that event are counted.

2.3.7.1 Performance Measurement Procedures

Performance can be measured by the following procedure:

- **Setting event mode.**
- **Setting minimum measurement unit for timer.**
- **Specify performance-buffer-full break.**
- **Setting events.**
- **Execute program.**
- **Display measurement result.**
- **Clear measurement result.**

■ Setting Event Mode

Set the event mode to the performance mode using the SET MODE command. This enables the performance measurement function.

[Example]

```
>SET MODE/PERFORMANCE
>
```

■ Setting Minimum Measurement Unit for Timer

It is 1ns as the minimum measurement unit for the timer used to measure performance. And a resolution of performance measurement data is 25ns.

■ Specify Performance-Buffer-Full Break

When the buffer for storing performance measurement data becomes full, a executing program can be broken. This function is called the performance-buffer-full break. The performance buffer becomes full when an event occurs 65535 times.

If the performance-buffer-full break is not specified, the performance measurement ends, but the program does not break.

[Example]

```
>SET PERFORMANCE/NOBREAK     <- Specifying Not Break
>
```

■ Setting Events

Set events using the SET EVENT command.

The starting/ending point of time measurement and points to measure pass count are specified by events.

Events at 8 points (1 to 8) can be set. However, in the performance measurement, the intervals, starting event number and ending event number are fixed in the following combination.

● Measuring Time

Four intervals have the following fixed event number combination.

Interval	Starting Event Number	Ending Event Number
1	1	2
2	3	4
3	5	6
4	7	8

- Measuring Count

  The specified events become performance measurement points automatically.

■ Executing Program

Start measuring when executing a program by using the GO or CALL command. If a break occurs during interval time measurement, the data for this specific interval is discarded.

■ Displaying Performance Measurement Data

Display performance measurement data by using the SHOW PERFORMANCE command.

■ Clearing Performance Measurement Data

Clear performance measurement data by using the CLEAR PERFORMANCE command.

[Example]

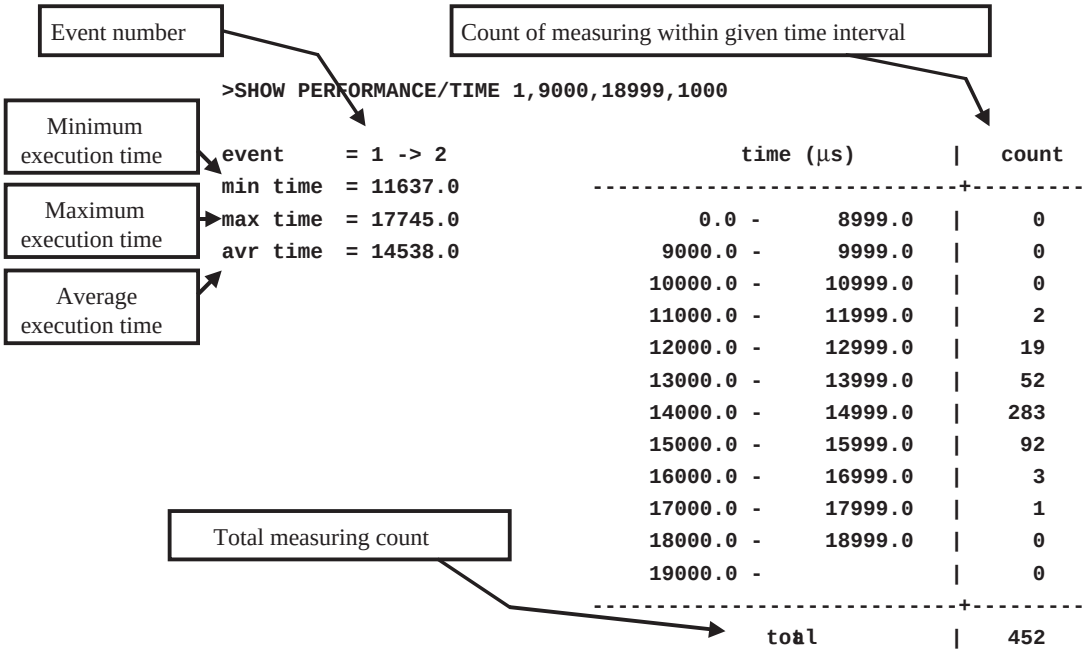
```
>CLEAR PERFORMANCE
>
```

2.3.7.2 Display Performance Measurement Data

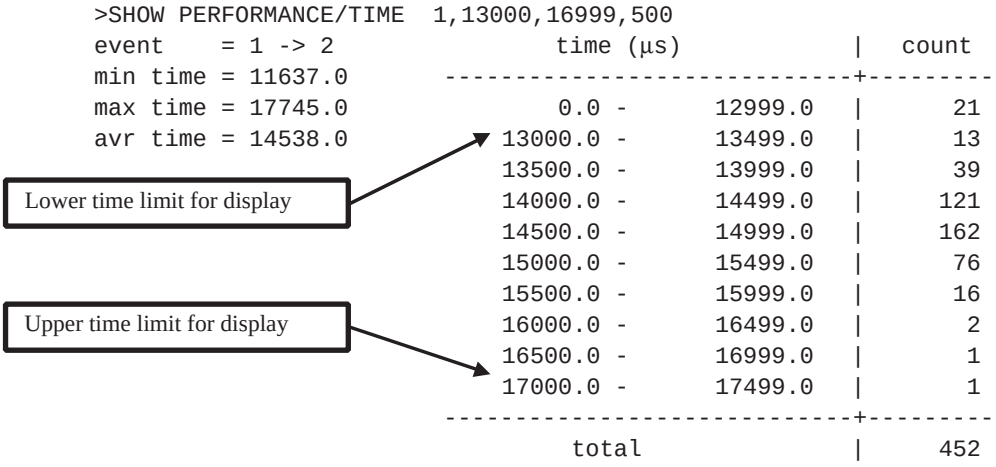
Display the measured time and measuring count by using the SHOW PERFORMANCE command.

■ Displaying Measured Time

To display the time measured, specify the starting event number or the ending event number.




```
>SHOW PERFORMANCE/TIME 1,9000,18999,1000
event     = 1 -> 2
min time  = 11637.0
max time  = 17745.0
avr time  = 14538.0
                          time (μs)          |   count
-----------------------------+---------
        0.0 -      8999.0   |      0
     9000.0 -      9999.0   |      0
    10000.0 -     10999.0   |      0
    11000.0 -     11999.0   |      2
    12000.0 -     12999.0   |     19
    13000.0 -     13999.0   |     52
    14000.0 -     14999.0   |    283
    15000.0 -     15999.0   |     92
    16000.0 -     16999.0   |      3
    17000.0 -     17999.0   |      1
    18000.0 -     18999.0   |      0
    19000.0 -               |      0
-----------------------------+---------
          total             |    452
```




```
>SHOW PERFORMANCE/TIME  1,13000,16999,500
event    = 1 -> 2
min time = 11637.0
max time = 17745.0
avr time = 14538.0
                          time (μs)          |   count
-----------------------------+---------
        0.0 -     12999.0   |     21
13000.0 -     13499.0   |     13
13500.0 -     13999.0   |     39
14000.0 -     14499.0   |    121
14500.0 -     14999.0   |    162
15000.0 -     15499.0   |     76
15500.0 -     15999.0   |     16
16000.0 -     16499.0   |      2
16500.0 -     16999.0   |      1
17000.0 -     17499.0   |      1
-----------------------------+---------
          total           |    452
```

2.3.8 Measuring Coverage

This emulator has the C0 coverage measurement function. Use this function to find what percentage of an entire program has been executed.

■ Coverage Measurement Function

When testing a program, the program is executed with various test data input and the results are checked for correctness. When the test is finished, every part of the entire program should have been executed. If any part has not been executed, there is a possibility that the test is insufficient.

This emulator coverage function is used to find what percentage of the whole program has been executed. In addition, details such as which addresses were not accessed can be checked.

This enables the measurement coverage range to be set.

To execute the C0 coverage, set a range within the code area. In addition, setting a range in the data area, permits checking the access status of variables such as finding unused variables, etc.

Execution of coverage measurement is limited to the address space specified as the debug area.

Therefore, set the debug area in advance.

This is operable by enabling the coverage function on the chip tabs: [Environment] - [Setup Debugging Environment] - [Debug Environment] menu.

■ Coverage Measurement Procedures

The procedure for coverage measurement is as follows:

1. Set range for coverage measurement:SET COVERAGE
2. Measuring coverage:GO, STEP, CALL
3. Displaying measurement result:SHOW COVERAGE

■ Coverage Measurement Operation

The following operation can be made in coverage measurement:

- Load/Save of coverage data: LOAD/COVERAGE, SAVE/COVERAGE
- Abortion and resume of coverage measurement: ENABLE COVERAGE, DISABLE COVERAGE
- Clearing coverage data: CLEAR COVERAGE
- Canceling coverage measurement range: CANCEL COVERAGE

Note:

When the coverage measurement function is used, the monitoring function in RAM area of the 0 bank cannot be used. For more details, refer to Section "2.3.9 Real-time Monitoring".

2.3.8.1 Coverage Measurement Procedures

The procedure for coverage measurement is as follows:

- **Set range for coverage measurement : SET COVERAGE**
- **Measure coverage : GO, STEP, CALL**
- **Display measurement result : SHOW COVERAGE**

■ Setting Range for Coverage Measurement

Use the SET COVERAGE command to set the measurement range. The measurement range can be set only within the area defined as the debug area. Up to 32 ranges can be specified.

By specifying /AUTOMATIC for the command qualifier, the code area for the loaded module is set automatically. However, the library code area is not set when the C compiler library is linked.

[Example]

```
>SET COVERAGE FF0000 .. FFFFFF
```

■ Measuring Coverage

When preparing for coverage measurement, execute the program.

Measurement starts when the program is executed by using the GO, STEP, or CALL command.

■ Displaying Coverage Measurement Result

To display the measurement result, use the SHOW COVERAGE command. The following can be displayed:

- Display coverage rate of total measurement area
- Displaying coverage rate of load module
- Summary of 16 addresses as one block
- Details indicating access status of each address
- Displaying coverage measurement result per source line
- Displaying coverage measurement result per machine instruction

● Display Coverage Rate of Total Measurement Area (Specify /TOTAL for command qualifier)

```
>SHOW COVERAGE/TOTAL
```

total coverage : 82.3%

● Displaying coverage rate of load module (Specify /MODULE for the command qualifier)

```
>SHOW COVERAGE/MODULE
sample.abs . . . . . (84.03%)
 +- startup.asm . . . . . (90.43%)
 +- sample.c . . . . . (95.17%)
 +- samp.c . . . . . (100.00%)
```

Displays the load modules and the coverage rate of each module.

- Summary (Specify /GENERAL for command qualifier)

```
>SHOW COVERAGE/GENERAL
  (HEX)0X0            +1X0            +2X0
        +---------------+---------------+------         ------
address 0123456789ABCDEF0123456789ABCDEF0123456    ... ABCDEF   C0(%)
FF0000  **3*F*......                                    32.0
```

Display the access status of every 16 addresses
- . : No access
- 1 to F : Display the number accessed in 16 addresses by the hexadecimal number.
- * : Access all of the 16 addresses.

- Details (Specify /DETAIL for command qualifier.)

Display one line of a coverage rate

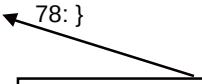
```
>SHOW COVERAGE/DETAIL FF0000

address +0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +A +B +C +D +E +F C0(%)
FF0000   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  - 100.0
FF0010   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  - 100.0
FF0020   .  .  .  .  -  -  -  .  .  .  .  .  .  .  .  .  18.6
FF0030   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  - 100.0
FF0040   -  .  -  -  -  -  -  -  -  -  -  -  -  -  -  -  93.7
FF0050   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  - 100.0
FF0060   .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .   0.0
FF0070   .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .   0.0
FF0080   .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .   0.0
```

Display the access status of every 1 address
- . : No access
- - : Access

- Displays per source line (Specify /SOURCE for the command qualifier)

```
>SHOW COVERAGE/SOURCE main
 *      70: {
        71:         int     i;
        72:         struct table *value[16];
        73:
 *      74:         for (i=0; i<16; i++)
 *      75:                 value[i] = &target[i];
        76:
 *      77:         sort_val(value, 16L);
 .      78: }
```

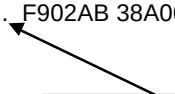


Displays access status of each source line.

. : No Access
* : Accessed
Blank: Line which the code had not been generated or is outside the scope of the coverage measurement

- Displays per machine instruction (Specify /INSTRUCTION for the command qualifier)

```
>SHOW COVERAGE/INSTRUCTION F9028F
sample.c$70 {
 *  F9028F                      \main:
 *  F9028F 0822                     LINK        #22
 *  F90291 4F01                     PUSHW   RW0
sample.c$74             for (i=0; i<16; i++)
 .  F90293 D0                       MOVN      A,#0
 .  F90294 CBFE                     MOVW      @RW3-02,A
 .  F90296 BBFE                     MOVW      A,@RW3-02
 .  F90298 3B1000                   CMPW      A,#0010
 .  F9029B FB18                     BGE       F902B5
sample.c$75                        value[i] = &target[i];
 .  F9029D BBFE                     MOVW      A,@RW3-02
 .  F9029F 0C                       LSLW      A
 .  F902A0 98                       MOVW      RW0,A
 .  F902A1 71F3DE                   MOVEA     A,@RW3-22
 .  F902A4 7700                     ADDW      RW0,A
 .  F902A6 4214                     MOV       A,#14
 .  F902A8 7833FE                   MULUW     A,@RW3-02
 .  F902AB 38A001                   ADDW      A,#01A0
```



Displays access status of each source line.

. : No Access
*: Accessed
Blank: Instruction outside the scope of the coverage measurement

2.3.9 Real-time Monitoring

The real-time monitoring function is used to display the memory contents during program execution.

■ Real-time Monitoring

The emulator can use the real-time monitoring function when the evaluation chip has the external trace bus interface.

A real-time monitoring window is provided to display two 256-byte regions for real-time monitoring purposes. The real-time monitoring window has a function for reading data from the actual memory and displaying it before program execution (copy function), and a function for displaying updated data in red.

■ When referring to RAM area of the 0 bank

To use the real-time monitoring function in the RAM area of the 0 bank, the coverage function must be disabled by the following methods.

- Command
  DISABLE COVERAGE
  Refer to "4.23 DISABLE COVERAGE" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  [Chip] tab on the Setup debug environment dialog.
  Refer to "4.7.2.3 Debug Environment" in "SOFTUNE Workbench Operation Manual".

2.3.10 Execution Time Measurement

This function measures the program execution time.

■ Measurement Items

Measures time between the start and stop of program execution.

In this emulator debugger, the measurement is performed by the emulation timer or cycle counter. The following shows the features.

- Emulation timer

  Resolution : 25 ns

  Significant bits: 56 bits

  Maximum measurement time : 72,057,594,037,927,935 × 25 ns
- Cycle counter

  Significant bits: 56 bits

  Maximum measurement cycle count : 72,057,594,037,927,935 cycles

In either case, the measurement is performed whenever a program is executed, and the measurement result displays the following two values:

- Number of cycles spent on the previous program execution
- Total number of cycles executed since the previous clearing

■ Displaying Measurement Results

Either of the following methods can be used to display the measurement results.

- Display by dialog

  The results appear in the time measurement dialog, which can be displayed by selecting [Debug] - [Time Measurement] menu.

  For details, refer to Section "4.6.8 Time Measurement" in "SOFTUNE Workbench Operation Manual".
- Display by command

  Enter the SHOW TIMER command in the command window.

  For details, refer to Section "4.27 SHOW TIMER" in "SOFTUNE Workbench Command Reference Manual".

■ Clearing Measurement Results

Either of the following methods can be used to clear the measurement results.

- Clearing by dialog

  Click the [Clear] button in the time measurement dialog, which can be displayed by selecting [Debug] - [Time Measurement] menu.

  For details, refer to Section "4.6.8 Time Measurement" in "SOFTUNE Workbench Operation Manual".

- Clearing by command

  Enter the CLEAR TIMER command in the command window.

  For details, refer to Section "4.28 CLEAR TIMER" in "SOFTUNE Workbench Command Reference Manual".

Note:

The measured execution time is added about ten extra cycles per execution. If the execution cycle is measured, execute many instructions continuously in order to minimize the effect of error.

2.3.11 Power-on Debugging

This section explains power-on debugging by the emulators for the MB2147-01.

■ Power-on Debugging

Power-ON debugging refers to the operation to debug the operating sequence that begins when the power to the target is switched on.

For products with a dedicated power-on debugging terminal, the MB2147-01 emulator can debug the sequence performed immediately after power-on. The following functions are available:

Code break
Data monitoring break
Data break
Sequencer and event
Trace trigger
Trace measurement
Coverage measurement

The power-on debugging procedure is described below:

- Set the DIP switch on the adapter board mounted in the upper part of the emulator.
- Turn on the target board and emulator main unit.
- Launch Workbench to start debugging.
  For debugging, set hardware breaks, etc.
- To start a power-on debugging, run [Execute] - [Power-ON Debug] menu.
  Input the lower limit value of the monitoring voltage from the [User Power Monitor Voltage] dialog box to display PON in the input status bar.
- Run the program.
- Turn the target board off while running and then back on.
- Conduct debugging.
- To terminate the power-on debugging, run [Execute] - [Power-ON Debug] menu.

2.3.12 RAM Checker

This section describes the functions of the RAM Checker.

■ Overview

The RAM checker obtains history logs of accessing the monitoring addresses on SOFTUNE Workbench and graphically displays log files using the accessory tool, "RAM Checker Viewer".

SOFTUNE Workbench has the following functions

- Sets monitoring addresses at 16 points
- Logs data access history of monitoring addresses at intervals of 1 ms
- Monitors monitoring addresses at intervals of 100 ms

■ RAM Check Window

The debugging window "RAM Checker" has been added to SOFTUNE Workbench to log/monitor monitoring addresses.

For operations of Ram checker Window, refer to Section "3.21 RAM Checker Window" of "SOFTUNE Workbench Operation Manual".

■ Use Conditions

The RAM Checker operates under the following conditions.

- Emulator: MB2147-01
- Communication device: USB

The RAM Checker cannot be used for the MB2141/MB2147-05 emulator, or the RS/LAN communication device. In those environments, the main menu [View] - [RAM Checker] is not disabled.

Note:

The RAM Checker is enabled only when the debug function on MB2147-01 is set to "RAM Checker" mode. For more details, see Section "2.3.1.6 Debug Function".

■ Specifications List

Monitoring Point Count	16 points
Size	Bytes/word (16 bits)
Event Functions	Max. 8 Points
Sampling Time	1 ms (Fixed)
Update Intervals	100 ms (Fixed)
Log File Formats	SOFTUNE format or CSV format

- SOFTUNE format
  - To display in the RAM Checker viewer (recommended)
  - Default extension is ".SRL".
- CSV format
  - To display in other applications than the RAM Checker viewer
  - Default extension is ".CSV".

Note:

The CSV format requires size of data approximately 4 times that of the SOFTUNE format.

■ To Use the RAM Checker

User sets the monitoring points, Log File, logging status by GUI or Command to use the RAM Checker.

- GUI
  - Set the debug function to "RAM Checker" mode by using [Debug] - [Select Debug Function].
  - By short cut menu [Setup...] on the Ram checker Window, user sets the monitoring points.
  - By short cut menu [File...] on the Ram checker Window, user sets the Log File.
  - By checking the short cut menu: [Logging start] on the Ram checker Window, a logging status of the Ram Checker becomes to enable.
- COMMAND
  - Set the debug function to "RAM Checker" mode by using SET MODE/CONFIG command.
  - By command: SET RAMCHECK, user sets the monitoring points.
  - By command: SET RAMCHECK, user sets the Log File.
  - By command: ENABLE RAMCHECK, a logging status of the Ram Checker becomes to enable.

After these commands are set, user program execute and Log File is created by stopped user program. If it is restarted, a Log File is overwritten.

Note:

If a setting of Overwrite control is enabled on Setup file dialog, a Log File is saved with different name every other execution.

For details about settings of the RAM Checker viewer, refer to Section "3.21 RAM Checker Window" of "SOFTUNE Workbench Operation Manual". and "4.47 SET RAMCHECK" to "4.51 DISABLE RAMCHECK" of "SOFTUNE Workbench Command Reference Manual".

Note:

Execution state for MCU such as stop mode or sleep mode cannot be displayed at status bar during logging.

■ About Log File

Following restrictions are made for the size of log file to be created depending on file system where log file is stored.

FAT:Up to 2GB

FAT32: Up to 4GB

NTFS: No limit.

Others: No limit

If the file system is FAT, FAT32, file name will be changed and continue logging when the size of file is exceeded limitation.

Note:

If a file is already existed, log file will be overwritten

Example of an operation

If the size of file is exceeded it's limitation, log file will be created as

filename.srl --> filename#1.srl

If the size gets exceeded the limitation again, log will be shown and changes as follows.

filename#1.srl --> filename#2.srl

•

•

filename#N-1.srl --> filename#N.srl

Notes:

- Log files should only be saved to built-in HDD only. If network, external HDD or external disk (CD, DVD, MO etc) are used as destination for saving files, files will not be saved.
- More than 500MB memory is required for disk to save log file of RAM checker. If the capacity of disk become less than 500MB, logging will be halted.

■ RAM Checker Viewer

The RAM Checker Viewer is a tool for graphically displaying changes in data values with the passage of time. There are the following three types of data display formats:

- Bit display (Logic Analyzer image)
- Data value display (bent line graph)
- Bit/data value display (simultaneous display bit and data values)

It displays halting CPU, trigger points and the Data Lost as other information.

To halt the operation of CPU, stop mode for low power consumption and power off condition at power-on debug function will be saved to log.

Trigger point uses event-hit in SOFTUNE Workbench. It is necessary to set event in SOFTUNE Workbench to use trigger point. When the event-hit is appeared, its information is recorded in a log.

The Data Lost is appeared in the following two causes.

- The Data Lost caused by hardware
  The emulator obtains data access history of RAM at intervals of 1 ms, but if two or more data access the same address within 1 ms, the emulator obtains only the data of the last access.
  Data loss caused by hardware indicates that several data accessed the same address.
- The Data Lost caused by software
  SOFTUNE Workbench obtains data from the emulator at intervals of 100 ms. However, other application may disable the SOFTUNE Workbench for obtaining data at intervals of 100 ms.
  In such cases, the RAM Checker Viewer does not display a portion of the data, but displays the invalid time band graphically.

Note:

If logging is halted by break or stopping an execution, software lost could be appeared for 1ms to 15ms. at the end of log. This happens because log after stopping an execution will be obtained until logging is stopped, thus this is not an actual data lost.

For details of RAM Checker viewer, refer to RAM Checker Viewer Manual (FswbRView.pdf) and Help.

2.3.13 Checking Debugger Information

This section explains how to check information about the MB2147-01 emulator debugger.

■ Debugger Information

This emulator debugger enables you to check the following information at startup.

- SOFTUNE Workbench file information
- Hardware information

If any errors have been discovered during SOFTUNE Workbench operations, check this information and contact our sales department or support department.

■ How to Check

Use one of the following methods to check debugger information.

- Command
  - SHOW SYSTEM
    Refer to Section "1.19 SHOW SYSTEM" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Version information dialog
    Select [Help] - [Version Information] menu.
    For details, refer to Section "4.9.3 Version Information" in "SOFTUNE Workbench Operation Manual".

■ Displayed Contents

```
F2MC-16 Family SOFTUNE Workbench VxxLxx
ALL RIGHTS RESERVED,
  COPYRIGHT(C) FUJITSU SEMICONDUCTOR LIMITED 1997
LICENCED MATERIAL -
  PROGRAM PROPERTY OF FUJITSU SEMICONDUCTOR LIMITED
=======================================================
Cpu information file path: CPU information file path
Cpu information file version: CPU information file version
=======================================================
Add in DLLs
-------------------------------------------------------
 SiCmn
 Product name: SOFTUNE Workbench
 File Path: SiC907.dll path
 Version: SiC907.dll version
- - - - - - - - - - - - - - - - - - - - - - - - - - - -
 SiiEd
 File Path: SiiEd3.ocx path
 Version: SiiEd3.ocx version
-------------------------------------------------------
 SiM907
 Product name: SOFTUNE Workbench
 File Path: SiM907.dll path
 Version: SiM907.dll version
- - - - - - - - - - - - - - - - - - - - - - - - - - - -
Language Tools
 - F2MC-16 Family SOFTUNE C Compiler version
   File Path: fcc907s.exe path
 - F2MC-16 Family SOFTUNE Assembler version
   File Path: fasm907s.exe path
```

```
 - F2MC-16 Family SOFTUNE Linker version
   File Path: flnk907s.exe path
 - F2MC-16 Family SOFTUNE Librarian version
   File Path: flib907s.exe path
 - SOFTUNE FJ-OMF to S-FORMAT Converter version
   File Path: f2ms.exe path
 - SOFTUNE FJ-OMF to INTEL-HEX Converter version
   File Path: f2is.exe path
 - SOFTUNE FJ-OMF to INTEL-EXT-HEX Converter version
   File Path: f2es.exe path
 - SOFTUNE FJ-OMF to HEX Converter version
   File Path: f2hs.exe path
-------------------------------------------------------
 SiOsM
 Product name: Softune Workbench
 File Path: SiOsM907.dll path
 Version: SiOsM907.dll version
-------------------------------------------------------
 F2MC-16 Series Debugger DLL
 Product name: SOFTUNE Workbench
 File Path: SiD907.dll path
 Version: SiD907.dll version
- - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Debugger type               : Current debugger type
MCU type                    : Currently selected target MCU
VCpu dll name               : Path and name of the currently used VCpu dll
VCpu dll version            : Version of the currently used virtual debugger DLL
DSU type                    : Currently used DSU type
Common version              : Version of monitor (common)
Monitor version             : Version of monitor (dependent)
Configuration board ID      : Configuration board ID
Configuration board version : Configuration board version
MCU frequency               : Operating frequency
Communication device        : Device type
Baud rate                   : Baud rate (at RS connection)
Host name                   : LAN host name (at LAN connection)
REALOS version              : REALOS version
-------------------------------------------------------
 SiIODef
 Product name: Softune Workbench
 File Path: SiIODef.dll path
 Version: SiIODef.dll version
=======================================================
Current path: Path of the currently used project
Language: Currently used language
Help file path: Help file path
```

2.4 Emulator Debugger (MB2147-05)

This section explains the functions of the emulator debuggers for the MB2147-05.

■ Emulator

When choosing the emulator debugger from the setup wizard, select one of the following emulators. The following description explains the case when MB2147-05 has been selected.

MB2141
MB2147-01
MB2147-05
MB2198

The emulator debugger for the MB2147-05 is software that controls an emulator from a host computer via a communications line (RS-232C or USB) to evaluate programs.

The following series can be debugged:

F^2MC-16L
F^2MC-16LX

Before using the emulator, it must be initialized. For details, refer to "Appendix B Downloading Monitor Program" of "SOFTUNE Workbench Operation Manual".

2.4.1 Setting Operating Environment

This section explains the operating environment setup.

■ Setting Operating Environment

For the emulator debugger for the MB2147-05, it is necessary to set the following operating environment. Predefined default settings for all these setup items are enabled at startup. Therefore, setup is not required when using the default settings. Adjusted settings can be used as new default settings from the next time.

- Monitoring program automatic loading
- MCU operation mode
- Debug area
- Memory mapping

2.4.1.1 Monitoring Program Automatic Loading

Emulators for MB2147-05 can automatically update the monitoring program at emulator startup.

■ Monitoring Program Automatic Loading

When the emulators for MB2147-05 is specified, data in the emulator can be checked at the beginning of debugging to load an appropriate monitoring program and configuration binary data automatically into the emulator.

The monitoring program and configuration binary data to be compared for update are in Lib\907 under the directory where Workbench is installed.

Enable/disable the monitoring program automatic loading function by choosing [Environment] - [Debugging Environment Setup] - [Setup Wizard] menu.

2.4.1.2 MCU Operation Mode

There are two MCU operation modes as follows:

- **Debugging Mode**
- **Native Mode**

■ Setting MCU Operation Mode

Set the MCU operation mode.

There are two operation modes: the debugging mode, and the native mode. Choose either one using the SET RUNMODE command.

At emulator start-up, the MCU is in the debugging mode.

The data access to internal bus may not be detected by emulator in native mode. Therefore, when the MCU operation mode is changed, all the following are initialized:

- Data breakpoints
- Trace measurement settings and trace buffer

■ Debugging Mode

All the operations of evaluation chips can be analyzed, but their operating speed is slower than that of mass-produced chips.

■ Native Mode

Evaluation chips have the same timing as mass-produced chips to control the operating speed. Note that the restrictions the shown in Table 2.4-1 are imposed on the debug functions.

Table 2.4-1 Restrictions on Debug Functions in Native Mode

Applicable series	Restrictions on debug functions
Common to all series	- When a data read access occurs on the MCU internal bus, the internal bus access information is not sampled and stored in the trace buffer. - Even when a data break or event (data access condition) is set for data on the MCU internal bus, it may not become a break factor or sequencer-triggering factor. - The coverage function may fail to detect an access to data on the MCU internal bus.

2.4.1.3 Debug Area

Set the intensive debugging area out of the whole memory space. The area functions are enhanced.

■ Setting Debug Area

There are two debug areas: DEBUG3, and DEBUG4. A continuous 1 MB area (16 banks) is set for each area.

Set the debug area using the SET DEBUG command.

Setting the debug area enhances the breakpoint function.

- Enhancement of Breakpoints

Up to six breakpoints (not including temporary breakpoints set using GO command) can be set when the debug area has not yet been set.

When setting the debug area as the CODE attribute, up to 65535 breakpoints can be set if they are within the area. At this time, up to six breakpoints can be set for an area other than the debug area, but the total count of breakpoints must not exceed 65535. In 00 to 0F bank and 0F0 to 0FF bank, a breakpoint can be set without specifying the debug area. (DEBUG1, DEBUG2)

2.4.1.4 Memory Area Types

A unit in which memory is allocated is called an area. There are five different area types.

■ Memory Area Types

A unit to allocate memory is allocated is called an area. There are five different area types as follows:

- User Memory Area

Memory space in the user system is called the user memory area and this memory is called the user memory. Up to four user memory areas can be set with no limit on the size of each area. Define a region on a 256-byte boundary.

Access attributes can be set for each area; for example, CODE, READ, etc., can be set for ROM area, and READ, WRITE, etc. can be set for RAM area. If the MCU attempts access in violation of these attributes, the MCU operation is suspended and an error is displayed (guarded access break).

To set the user memory area, use the SET MAP command.

- Emulation Memory Area

Memory space substituted for emulator memory is called the emulation memory area, and this memory is called emulation memory.

It is possible to set up to four areas of 256-KB maximum (including an internal ROM area described later) as emulation memory area. Define a region on a 256-byte boundary. An area larger than 256-KB can be specified at one time but is divided internally into two or more 256-KB areas for management purposes.

Memory manipulation commands can be executed in relation to emulation memory areas while MCU execution is in progress.

Emulation memory areas can be set using the SET MAP command.

Further, the access attributes can be set as with user memory areas.

Note:

Even if the MCU internal resources are set as emulation memory area, access is made to the internal resources.

- Internal ROM Area

The area where the emulator internal memory is substituted for internal ROM is called the internal ROM area, and this memory is called the internal ROM memory.

Only one internal ROM area with a size up to 256-KB can be specified.

The internal ROM area with a size up to 1 MB can be specified 2 areas.

Memory manipulation commands can be executed in relation to emulation memory areas while MCU execution is in progress.

The internal ROM area is capable to set by the "Setup Map" dialog opening by "Debugger Memory Map... " from "Setup".

Note:

The internal memory area, it is set a suitable area automatically by the selected MCU.

- Internal ROM Image Area

Some types of MCUs have data in a specific area of internal ROM appearing to 00 bank. This specific area is called the internal ROM image area.

The internal ROM image area is capable to set by the "Setup Map" dialog opening by "Debugger Memory Map... " from "Setup". This area attribute is automatically set to READ/CODE. The same data as in the internal ROM area appears in the internal ROM image area.

Note that the debug information is only enabled for either one (one specified when linked). To debug only the internal ROM image area, change the creation type of the load module file.

Note:

The internal memory area, it is set a suitable area automatically by the selected MCU.

- Undefined Area

A memory area that does not belong to any of the areas described above is part of the user memory area. This area is specifically called the undefined area.

The undefined area can be set to either NOGUARD area, which can be accessed freely, or GUARD area, which cannot be accessed. Select either setup for the whole undefined area. If the area attribute is set to GUARD, a guarded access error occurs if access to this area is attempted.

2.4.1.5 Memory Mapping

Memory space can be allocated to the user memory and the emulation memory, etc., and the attributes of these areas can be specified.
However, the MCU internal resources are not dependent on this mapping setup and access is always made to the internal resources.

■ Access Attributes for Memory Areas

The access attributes shown in Table 2.4-2 can be specified for memory areas.

A guarded memory access break occurs if access is attempted in violation of these attributes while executing a program.

When access to the user memory area and the emulation memory area is made using program commands, such access is allowed regardless of the CODE, READ, WRITE attributes. However, access to memory with the GUARD attribute in the undefined area, causes an error.

Table 2.4-2 Types of Access Attributes

Area	Attribute	Description
User Memory Emulation Memory	CODE	Instruction Execution Enabled
	READ	Data Read Enabled
	WRITE	Data Write Enabled
Undefined	GUARD	Access Disabled
	NOGUARD	No check of access attribute

When access is made to an area without the WRITE attribute by executing a program, a guarded access break occurs after the data has been rewritten if the access target is the user memory. However, if the access target is the emulation memory, the break occurs before rewriting. In other words, write-protection (memory data cannot be overwritten by writing) can be set for the emulation memory area by not specifying the WRITE attribute for the area.

This write-protection is only enabled for access made by executing a program, and is not applicable to access by commands.

■ Creating and Viewing Memory Map

Use the following commands for memory mapping.

SET MAP:	Set memory map.
SHOW MAP:	Display memory map.
CANCEL MAP:	Change memory map setting to undefined.

[Example]

```
>SHOW MAP
address                 attribute           type
000000 .. FFFFFF        noguard
The rest of setting area numbers
user = 8    emulation = 5
>SET MAP/USER H'0..H'1FF
>SET MAP/READ/CODE/EMULATION H'FF0000..H'FFFFFF
>SET MAP/USER H'8000..H'8FFF
>SET MAP/MIRROR/COPY H'8000..H'8FFF
>SET MAP/GUARD
>SHOW MAP
address                 attribute           type
000000 .. 0001FF        read write          user
000200 .. 007FFF        guard
008000 .. 008FFF        read write          user
009000 .. FEFFFF        guard
FF0000 .. FFFFFF        read write cod e    emulation
mirror address area
008000 .. 008FFF        copy
The rest of setting area numbers
user = 6    emulation = 3
>
```

■ Internal ROM Area Setting

The [Setup Map] dialog box is displayed using [Environment] - [Debugger Memory Map] menu. You can set the internal ROM area using the [Internal ROM Area] after the [Map Adding] dialog box is displayed by clicking on the [Setting] button. You can set two areas. Both require empty Emulation area to be set. You can set the region size by (Empty space of the emulation area) x (one area size).

Specify the internal ROM area from the ending address H'FFFFFF (fixed) for area 1. Also, it is possible to delete the internal ROM area.

2.4.2 Notes on Commands for Executing Program

When using commands to execute a program, there are several points to note.

■ Notes on GO Command

For the GO command, two breakpoints that are valid only while executing commands can be set. However, care is required in setting these breakpoints.

- Invalid Breakpoints

- No break occurs when a breakpoint is set at the instruction immediately after the following instructions.

F^2MC-16L/16LX	PCB NCC SPB MOV ILM,#imm8 ORCCR,#imm8	DTB ADB CNR ANDCCR,#imm8 POPW PS

- No break occurs when breakpoint set at address other than starting address of instruction.
- No break occurs when both following conditions met at one time.
  - Instruction for which breakpoint set starts from odd-address,
  - Preceding instruction longer than 2 bytes length, and breakpoint already set at last 1-byte address of preceding instruction (This "already-set" breakpoint is an invalid breakpoint that won't break, because it has been set at an address other than the starting address of an instruction).

- Abnormal Breakpoint

Setting a breakpoint at the instruction immediately after string instructions listed below, may cause a break in the middle of the string instruction without executing the instruction to the end.

F^2MC-16L/16LX	MOVS SECQ WBTS MOVSWI SECQWI MOVSD SECQD FILS FILSW	MOVSW SECQW MOVSI SECQI WBTC MOVSWD SECQWD FILSI FILSWI

■ Notes on STEP Command

● Exceptional Step Execution

When executing the instructions listed in the notes on the GO command as invalid breakpoints and abnormal breakpoints, such instructions and the next instruction are executed as a single instruction. Furthermore, if such instructions are continuous, then all these continuous instructions and the next instruction are executed as a single instruction.

● Step Execution that won't Break

Note that no break occurs after step operation when both the following conditions are met at one time.

- When step instruction longer than 2 bytes length and last code ends at even address
- When breakpoint already set at last address (This "already-set" breakpoint is an invalid breakpoint that won't break, because it has been set at an address other than the starting address of an instruction.)

■ Controlling Watchdog Timer

It is possible to select "No reset generated by watchdog timer counter overflow" while executing a program using the GO, STEP, CALL commands.

Use the ENABLE WATCHDOG, DISABLE WATCHDOG commands to control the watchdog timer.

- ENABLE WATCHDOG : Reset generated by watchdog timer counter overflow
- DISABLE WATCHDOG : No reset generated by watchdog timer counter overflow

The start-up default in this program is "Reset generated by watchdog timer counter overflow".

[Example]

```
>DISABLE WATCHDOG
>GO
```

2.4.3 Commands Available during Execution of User Program

This section explains the commands available during the execution of a user program.

■ Commands Available during Execution of User Program

This emulator debugger allows you to use certain commands during the execution of a user program.

For more details, see "■ Debugger" in "SOFTUNE Workbench Command Reference Manual".

The double circle indicates that it is available during the execution of a user program.

Table 2.4-3 shows the commands available during the execution of a user program.

Table 2.4-3 Commands Available during Execution of User Program

Function	Restrictions	Major Commands
MCU reset	-	1.3 RESET
Memory operation (Read/Write)	Emulation memory only operable	5.1 EXAMINE, 5.2 ENTER, 5.3 SET MEMORY, 5.4 SHOW MEMORY, 5.5 SEARCH MEMORY, 5.8 COMPARE, 5.9 FILL, 5.10 MOVE, 5.11 DUMP
Line assembly, Disassembly	Emulation memory only enabled	6.1 ASSEMBLE, 6.2 DISASSEMBLE

Notes:

- The conditions which allow you to use the commands in Table 2.4-3 are limited to the following cases when a user program is executed.
  - [Debug] - [Run] - [Go] menu
  - [Go] button on the debug toolbar

  The commands in Table 2.4-3 cannot be used when the GO command is entered in the command window.
- An error message appears if you enter a command that cannot be used during the execution of a user program.

  "E4404S Command error (MCU is busy)."

2.4.4 Break

In this emulator debugger, five kinds of break functions can be used. When the program execution is aborted by each break function, the address and the break factor to do the break are displayed.

■ Break Functions

In this emulator debugger, five kinds of break functions are supported.

- Code break
- Data break
- Guarded access break
- Trace-buffer-full break
- Forced break

2.4.4.1 Code Break

It is a function to abort the program execution by observing the specified address. The break is done before an instruction the specified address is executed.

■ Code Break

It is a function to abort the program execution by observing the specified address. The break is done before an instruction the specified address is executed. It is possible to set it in this 65535 debuggers. However, it is necessary to set the debugging area as a code break area.

When a break occurs due to a code break, the following message is displayed on the Status Bar.

Break at Address by breakpoint

■ Setting Method

The code break is controlled by the following method.

- Command
  - SET BREAK
    Refer to "3.1 SET BREAK (type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Breakpoints set dialog [Code] tab
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".
- Window
  - Source window/Disassembly window

■ Notes on Code Break

There are several points to note in using code break. First, some points affecting code break are explained.

● Invalid Breakpoints

- No break occurs when a breakpoint is set at the instruction immediately after the following instructions.

  F^2MC-16/16L/16LX/16H: • PCB • DTB • NCC • ADB • SPB • CNR
  • MOV ILM,#imm8 • AND CCR,#imm8
  • OR CCR,#imm8 • POPW PS

  F^2MC-16F: • PCB • DTB • NCC • ADB • SPB • CNR
- No break occurs when breakpoint set at address other than starting address of instruction.
- No break occurs when both following conditions met at one time.
  - Instruction for which breakpoint set starts from odd-address
  - Preceding instruction longer than 2 bytes length, and breakpoint already set at last 1-byte address of preceding instruction (This "already-set" breakpoint is an invalid breakpoint that won't break, because it has been set at an address other than the starting address of an instruction.)

● Abnormal Breakpoint

- Setting a breakpoint at the instruction immediately after string instructions listed below, may cause a break in the middle of the string instruction without executing the instruction to the end.

F^2MC-16/16L/16LX/16H:	• MOVS	• MOVSW	• SECQ	• SECQW	• WBTS
	• MOVSI	• MOVSWI	• SECQI	• SECQWI	• WBTC
	• MOVSD	• MOVSWD	• SECQD	• SECQWD	
	• FILS	• FILSI	• FILSW	• FILSWI	
F^2MC-16F:	Above plus	• MOVM	• MOVMW		

Here are some additional points about the effects on other commands.

● Dangerous Breakpoints

- Never set a breakpoint at an address other than the instruction starting address. If a breakpoint is the last 1 byte of an instruction longer than 2 bytes length, and if such an address is even, the following abnormal operation will result:
  - If instruction executed by STEP command, instruction execution not aborted.
  - If breakpoint specified with GO command, set at instruction immediately after such instruction, the breakpoint does not break.

Note:

When the debugging area is set again, all breakpoints in the area are cleared.

2.4.4.2 Data Break

The data break is a function to abort the program execution when the data access (read or write) is done to the address specified while executing the program.

■ Data Break

The data break is a function to abort the program execution when MCU accesses data as for a specified address.

When a break occurs due to a data break, the following message is displayed on the Status Bar.

Break at Address by databreak at Access address

■ Setting Method

The data break is controlled by the following method.

- Command
  - SET DATABREAK
    Refer to "3.9 SET DATABREAK (type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Breakpoints set dialog [Data] tab
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".

Note:

When the debugging area is set again, all breakpoints in the area are cleared.

2.4.4.3 Guarded Access Break

The guarded access break is an abortion of the program execution that happens when the violation to the set access attribute, doing the access, and guarded (An undefined area cannot be accessed) area are accessed.

■ Guarded Access Break

A guarded access break aborts a executing program when access is made in violation of the access attribute set by using the [Setup] - [Memory Map] menu, and access is attempted to a guarded area (access-disabled area in undefined area).

There are three types of the following in Guarded access break.

Code guarded

When the instruction execution is done to the area without the code attribute, the break is done.

Read guarded

When the area without the read attribute is read, the break is done.

Write guarded

When the area without the write attribute is write, the break is done.

If a guarded access occurs while executing a program, the following message is displayed on the Status Bar and the program is aborted.

Break at Address by guarded access {code/read/write} at Access address

Note:

Code Guarded is affected by pre-fetching.

The F^2MC-16L/16LX/16/16H family pre-fetch up to 4 bytes. So, when setting the program area mapping, set a little larger area (5 bytes max.) than the program area actually used.

Similarly, the F^2MC-16F family pre-fetch up to 8 bytes. So, when setting the program area mapping, set a little larger area (9 bytes max.) than the program area actually used.

2.4.4.4 Trace-Buffer-Full Break

It is a function to abort the program execution when the trace buffer becomes full.

■ Trace-Buffer-Full Break

It is a function to abort the program execution when the trace buffer becomes full.

When a break occurs due to a trace-buffer-full break, the following message is displayed on the Status Bar.

Break at Address by trace buffer full

■ Setting Method

The trace-buffer-full break is controlled by the following method.

- Command
  - SET TRACE/BREAK
    Refer to "4.30 SET TRACE (type 2)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Trace Set Dialog
    Refer to "4.4.8 Trace" in "SOFTUNE Workbench Operation Manual".

2.4.4.5 Forced Break

It is a function to abort the execution of the program compulsorily.

■ Forced Break

It is a function to abort the execution of the program compulsorily.

When a break occurs due to a forced break, the following message is displayed on the Status Bar.

Break at Address by command abort request

Note:

A forced break is not allowed while the MCU is in the low-power consumption mode or hold state. When a forced break is requested by the [Debug] - [Abort] menu while executing a program, the menu is disregarded if the MCU is in the low-power consumption mode or hold state. If a break must occur, then reset the cause at user system side, or reset the cause by using the [Debug] - [Reset MCU] menu, after inputting the [Debug] - [Abort] menu.

When the MCU enters the power-save consumption mode or hold state while executing, the status is displayed on the Status Bar.

2.4.5 Real-time Trace

While execution a program, the address, data and status information, and the data sampled by an external probe can be sampled in machine cycle units and stored in the trace buffer. This function is called real-time trace.
In-depth analysis of a program execution history can be performed using the data recorded by real-time trace.

■ Trace Buffer

The data recorded by sampling in machine cycle units, is called a frame.

The trace buffer can store 64K frames (65536). Since the trace buffer has a ring structure, when it becomes full, it automatically returns to the start to overwrite existing data.

■ Trace Data

Data sampled by the trace function is called trace data.

The following data is sampled:

- Address
- Data
- Status Information
  - Access status: Read/Write/Internal access, etc.
  - Device status: Instruction execution, Reset, Hold, etc.
  - Queue status: Count of remaining bytes of instruction queue, etc.
  - Data valid cycle information: Data valid/invalid
    (Since the data signal is shared with other signals, it does not always output data. Therefore, the trace samples information indicating whether or not the data is valid.)

■ Data Not Traced

The following data does not leave access data in the trace buffer.

- Portion of access data while in native mode.

When operating in the native mode, the F^2MC-16L/16LX family of chips sometime performs simultaneous multiple bus operations internally. However, in this emulator, monitoring of the internal ROM bus takes precedence. Therefore, other bus data being accessed simultaneously may not be sampled (in the debugging mode, all operations are sampled).

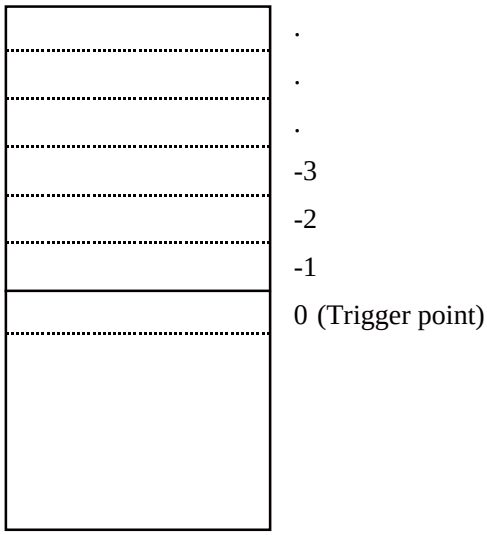
■ Frame Number

A number is assigned to each frame of sampled trace data. This number is called a frame number.

The frame number is used to specify the display start position of the trace buffer. The value 0 is assigned to trace data at the triggering position for sequencer termination. Negative values are assigned to trace data that have been sampled before arrival at the triggering position (See Figure 2.4-1).

If there is no triggering position for sequencer termination, the value 0 is assigned to the last-sampled trace data.

Figure 2.4-1 Frame Number at Tracing



■ Trace Filter

To make effective use of the limited trace buffer capacity, in addition to the code fetch function, a trace filter function is incorporated to provide a means of acquiring information about data accesses to a specific region.

The data trace filter function allows the following values to be specified for two regions:

- Address
- Address mask
- Access attribute (read/write)

Another function can be used so that sampling of redundant frames occupying two or more trace frames, such as SLEEP and READY, can be reduced to sampling of one frame.

2.4.5.1 Setting Trace

To perform a trace, follow steps (1), (2) below. When a program is executed after completion of the following steps, trace data is sampled.
(1) Enable the trace function.
(2) Perform trace-buffer-full break setup.

■ Setting Trace

To perform a trace, complete the following setup steps. When a program is executed after completion of the steps, trace data is sampled.

1) Enable the trace function.

Enable the trace function using the ENABLE TRACE command.

To disable the trace function, use the DISABLE TRACE command.

The trace function is enabled by default when the program is launched.

2) Perform trace-buffer-full break setup.

A break can be invoked when the trace buffer becomes full.

To perform setup, use the SET TRACE command. This break feature is disabled when the program starts. To view the setting, use SHOW TRACE/STATUS.

Table 2.4-4 shows the commands related to a trace.

Table 2.4-4 Trace-related Commands

Available command	Function
SET TRACE	Sets trace-buffer-full break
SHOW TRACE	Displays trace data
SEARCH TRACE	Searches for trace data
ENABLE TRACE	Enables trace function
DISABLE TRACE	Disables trace function
CLEAR TRACE	Clears trace function

2.4.5.2 Displaying Trace Data Storage Status

It is possible to displays how much trace data is stored in the trace buffer. This status data can be read by specifying /STATUS to the SHOW TRACE command.

■ Displaying Trace Data Storage Status

It is possible to displays how much trace data is stored in the trace buffer. This status data can be read by specifying /STATUS to the SHOW TRACE.

[Example]

```
>SHOW TRACE/STATUS
en/dis      = enable            ; Trace function enabled
buffer full = nobreak           ; Buffer full break function disabled
sampling    = end               ; Trace sampling terminates
frame no. = -00120 to  00050    ; Frame -120 to 50 store data
step no.  = -00091 to  00022    ; Step -91 to 22 store data
>
```

2.4.5.3 Specifying Displaying Trace Data Start

The data display start position in the trace buffer can be specified by inputting a step number or frame number using the SHOW TRACE command. The data display range can also be specified.

■ Specifying Displaying Trace Data Start

Specify the data display start position in the trace buffer by inputting a step number or frame number using the SHOW TRACE command. The data display range can also be specified.

[Example]

- In Single Trace Mode

```
>SHOW TRACE/CYCLE -6          ; Start displaying from frame -6
>SHOW TRACE/CYCLE -6..10      ; Display from frame -6 to frame 10
>SHOW TRACE -6                ; Start displaying from step -6
>SHOW TRACE -6..10            ; Displays from step -6 to step 10
```

2.4.5.4 Display Format of Trace Data

The trace data display format can be selected by running the SHOW TRACE command with a command modifier specified. If setup is completed with the SET SOURCE command so as to select a source line addition mode, a source line is attached to the displayed trace data.

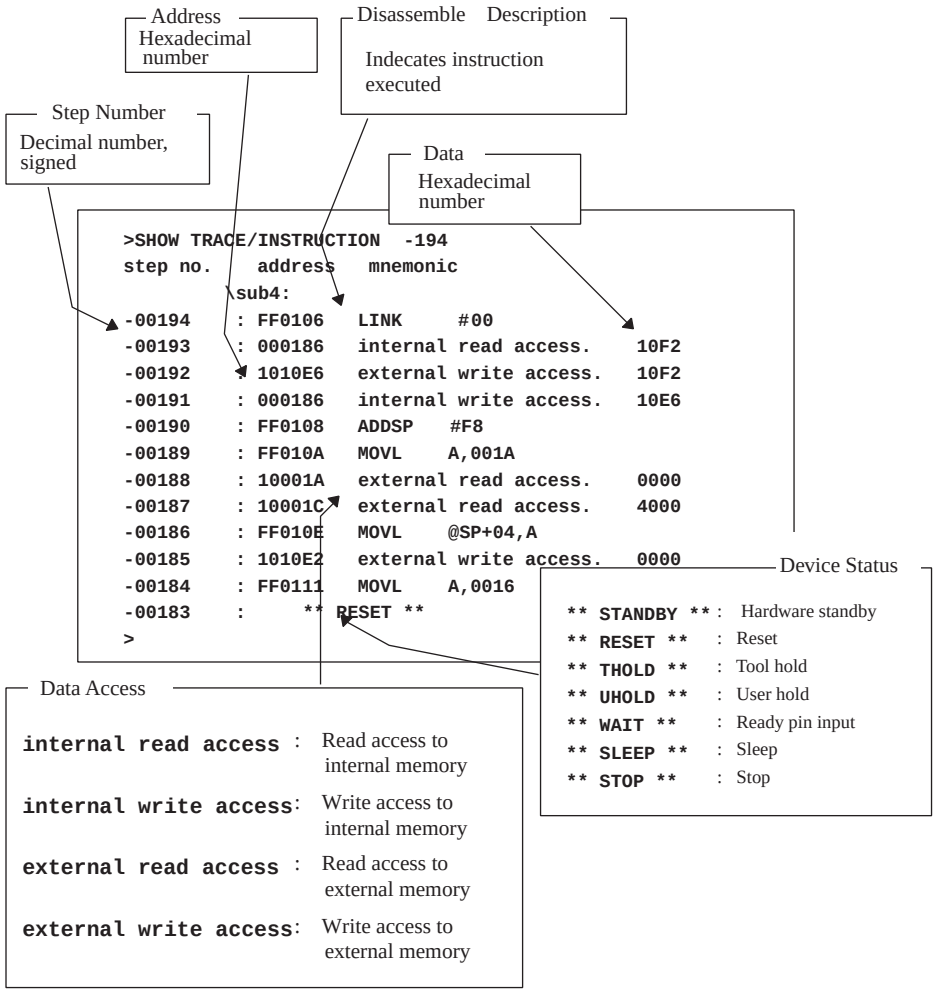
There are three formats to display trace data:

- **Display in instruction execution order (Specify /INSTRUCTION.)**
- **Display all machine cycles (Specify /CYCLE.)**
- **Display in source line units (Specify /SOURCE.)**

■ Display in Instruction Execution Order (Specify /INSTRUCTION.)

Trace sampling is performed at each machine cycle, but the sampling results are difficult to display because they are influenced by pre-fetch, etc. This is why the emulator has a function to allow it to analyze trace data as much as possible. The resultant data is displayed after processes such as eliminating pre-fetch effects, analyzing execution instructions, and sorting in instruction execution order are performed automatically. However, this function can be specified only in the single trace while in the debugging mode.

In this mode, data can be displayed in the following format.



■ Displaying All Machine Cycles

Detailed information at all sampled machine cycles can be displayed.

In this mode, no source is displayed irrespective of the setup defined by the SET SOURCE command.

[Example]

```
>SHOW TRACE/CYCLE -587
frame no. address   data  a-status  d-status  Qst   dfg
-00587    : FF0106  0106  ---       -------   FLH
-00586    : FF0106  0008  ECF       EXECUTE   ---   @
-00585    : FF0106  0106  ---       EXECUTE   ---
-00584    : 1010E8  10E8  ---       -------   ---
-00583    : 1010E8  0102  EWA       EXECUTE   ---   @
-00582    : 1010E8  0102  ---       EXECUTE   ---
-00581    : 000186  0186  ---       -------   2by
-00580    : 000186  10F2  IRA       EXECUTE   ---   @
-00579    : 1010E6  10E6  ---       -------   ---
-00578    : 1010E6  10F2  EWA       EXECUTE   ---   @
-00577    : 1010E6  10F2  ---       EXECUTE   ---
-00576    : 000186  0186  ---       -------   ---
```

How to read trace data

frame no.	address	data	a-status	d-status	Qst	dfg
(1)	(2)	(3)	(4)	(5)	(6)	(7)

(1):frame number (Decimal, signed)

(2):executed instruction address, and data access address (Hexadecimal number)

(3):data (Hexadecimal number)

(4):access information (a-status)

WA:write access to internal memory
EWA:write access to external memory
IRA:read access to internal memory
ERA:read access to external memory
ICF:code fetch to internal memory
ECF:code fetch to external memory
---:valid "d-status" information

(5):device information (d-status)

STANDBY:hardware standby
THOLD :tool hold
UHOLD :user hold
WAIT :waiting by ready pin
SLEEP :sleep
STOP :stop
EXECUTE:execute instruction
RESET :reset
-------:invalid d-status information

(6):instruction queue status

FLH:flush queue
-by:number of remainder code of queue is -byte(-:1 to 8)

(7):valid flag

&:this frame address is valid
@:this frame data is valid

■ Display in Source Line Units (Specify /SOURCE.)

Only the source line can be displayed. This mode is enabled only in the debugging mode.

[Example]

```
>SHOW TRACE/SOURCE -194
step no.   source
-00194     : gtg1.c$251  {
-00190     : gtg1.c$255        sub5(nf, nd);
-00168     : gtg1.c$259  {
-00164     : gtg1.c$264        p = (char *)  &df;
-00161     : gtg1.c$264        p = (char *)  &df;
-00157     : gtg1.c$265        *(p++) = 0x00;
-00145     : gtg1.c$266        *(p++) = 0x00;
-00133     : gtg1.c$267        *(p++) = 0x80;
-00121     : gtg1.c$268        *p     = 0x7f;
-00116     : gtg1.c$270        p = (char *)  &dd;
-00111     : gtg1.c$271        *(p++) = 0xff;
-00099     : gtg1.c$272        *(p++) = 0xff;
```

Note:

The following operation may be subjected to trace sampling immediately after the MCU operation is stopped (tool hold). Remember that the operation is unique to evaluation chips and not performed by mass-produced products.

Access to address 0x000100 and addresses between 0x0FFFFDC and 0x0FFFFFF

2.4.5.5 Reading Trace Data On-the-fly

Trace data can be read while executing a program. However, this is not possible during sampling. Disable the trace function or terminate tracing before attempting to read trace data.

■ Reading Trace Data On-the-fly

To disable the trace function, use the DISABLE TRACE command. Check whether or not the trace function is currently enabled by executing the SHOW TRACE command with /STATUS specified, or by using the built-in variable, %TRCSTAT.

Tracing terminates when the sequencer has terminated. If Not Break is specified here, tracing terminates without a break operation. It is possible to check whether or not tracing has terminated by executing the SHOW TRACE command with /STATUS specified, or by using the built-in variable, %TRCSAMP.

To read trace data, use the SHOW TRACE command; to search trace data, use the SEARCH TRACE command.

[Example]

```
>GO
>>SHOW TRACE/STATUS
en/dis       = enable
buffer full  = nobreak
sampling     = on            <- Trace sampling continues.
>>SHOW TRACE/STATUS
en/dis       = enable
buffer full  = nobreak
sampling     = end           <- Trace sampling ends.
frame no.    = -00805 to  00000
step no.     = -00262 to  00000
>>SHOW TRACE -52
step no.  address   mnemonic                    level
\sub5:
-00052    : FF0125  LINK      #02    1
-00051    : 000186  internal  read access.    10E6  1
-00050    : 1010D6  external  write access.   10E6  1
-00049    : 000186  internal  write access.   10D6  1
```

If the CLEAR TRACE command is executed with the trace ending state, trace data sampling can be re-executed by re-executing the sequencer from the beginning.

2.4.5.6 Saving Trace Data

This section explains how to save trace data.

■ Saving Trace Data

Trace data can be saved in a specified file.

The following two methods are available to save trace data: using GUI (window or dialog) and using only the command. The same result is obtained from both methods.

● Using GUI for Saving Trace Data

1. Display the trace window.
   - Select [View] - [Trace] menu.
2. Specify the name of the file in which to save trace data.
   - Right-click on the trace window, and select [Save] from the shortcut menu. The [Save as] dialog appears.
     Specify the file name and where to save trace data. For details, refer to Section "4.4.8 Trace" in "SOFTUNE Workbench Operation Manual".

● Using Command for Saving Trace Data

1. Save trace data.
   - Execute the SHOW TRACE/FILE command.
     For details, refer to Section "4.33 SHOW TRACE (type 3)" in "SOFTUNE Workbench Command Reference Manual".
     When additionally saving trace data in an existing file, execute the SHOW TRACE/FILE/APPEND command.

2.4.6 Measuring Execution Cycle Count

This function measures the program execution cycle count.

■ Measurement Items

Measures cycle count between the start and stop of program execution.

In this emulator debugger, the measurement is performed by the cycle counter. The following shows the features of the cycle counter.

Significant bits : 56 bits

Maximum measurement cycle count : 72,057,594,037,927,935 cycles

The measurement is performed whenever a program is executed, and the measurement result displays the following two values:

- Number of cycles spent on the previous program execution
- Total number of cycles executed since the previous clearing

■ Displaying Measurement Results

Either of the following methods can be used to display the measurement results.

- Display by dialog

  The results appear in the time measurement dialog, which can be displayed by selecting [Debug] - [Time Measurement] menu.

  For details, refer to Section "4.6.8 Time Measurement" in "SOFTUNE Workbench Operation Manual".

- Display by command

  Enter the SHOW TIMER command in the command window.

  For details, refer to Section "4.27 SHOW TIMER" in "SOFTUNE Workbench Command Reference Manual".

■ Clearing Measurement Results

Either of the following methods can be used to clear the measurement results.

- Clearing by dialog

  Click the [Clear] button in the time measurement dialog, which can be displayed by selecting [Debug] - [Time Measurement] menu.

  For details, refer to Section "4.6.8 Time Measurement" in "SOFTUNE Workbench Operation Manual".

- Clearing by command

  Enter the CLEAR TIMER command in the command window.

  For details, refer to Section "4.28 CLEAR TIMER" in "SOFTUNE Workbench Command Reference Manual".

Note:

The measured number of execution cycles is added about ten extra cycles per execution. If the execution cycle is measured, execute many instructions continuously in order to minimize the effect of error.

2.5 Emulator Debugger (MB2198)

This section explains the functions of the emulator debuggers for the MB2198.

■ Emulator Debugger

When choosing the emulator debugger from the setup wizard, select one of the following emulators. The following description explains the case when MB2198 has been selected.

- MB2141
- MB2147-01
- MB2147-05
- MB2198

The emulator debugger for the MB2198 is software that controls an emulator from a host computer via a communications line (RS-232C, LAN, or USB) to evaluate programs.

The following series can be debugged:

F^2MC-16FX

Before using the emulator, the emulator must be initialized.

For further details, refer to "Appendix B Download Monitor Program", and "Appendix C Setting up LAN Interface" of "SOFTUNE Workbench Operation Manual".

2.5.1 Setting Operating Environment

This section explains the operating environment setup.

■ Setting Operating Environment

For the emulator debugger for the MB2198, it is necessary to set the following operating environment.

Predefined default settings for all these setup items are enabled at startup. Therefore, setup is not required when using the default settings. Adjusted settings can be used as new default settings from the next time.

- Monitor program automatic load
- Boot ROM file automatic execution
- MCU operation mode
- Operation frequency control

2.5.1.1 Monitoring Program Automatic Loading

The MB2198 emulator can automatically update the monitoring program at emulator startup.

■ Monitoring Program Automatic Loading

When the MB2198 emulator is specified, data in the emulator can be checked at the starting of debugging to load an appropriate monitoring program and configuration binary data automatically into the emulator.

The monitoring program and configuration binary data to be compared for update are in Lib\907 under the directory where Workbench is installed.

Enable/disable the monitoring program automatic loading function by choosing [Environment] - [Debug Environment] - [Setup Wizard] menu.

2.5.1.2 Boot ROM File Automatic Execution

The MB2198 emulator automatically loads and executes the Boot ROM file during startup of the debug.

■ Boot ROM File Automatic Execution

When the MB2198 emulator is specified, at the starting of debugging the Boot ROM file is automatically loaded and then executed. The Boot ROM file is in Lib\907\BootROM under the directory where Workbench is installed.

The directory containing the Boot ROM file can be displayed using the [Project] - [Setup Project] menu, and can be modified in the setup project dialog. In addition, it is also possible to automatically execute the Boot ROM file during the debugger startup or reset of MCU. For details, see the "SOFTUNE Workbench Operation Manual".

Notes:

- As the Boot ROM file contains information necessary for launching the emulator debugger, it must be executed during startup of the debugger or upon reset. If the execution is not performed, the debugger may not operate properly.
- The PC value when MCU reset has been performed in the emulator debugger varies depending on whether it is MB2198 or not as follows:

  MB2198: Starting address of the Boot ROM file

  Other than MB2198: Entry point in the target file (reset vector)

2.5.1.3 MCU Operation Mode

There are two MCU operation modes as follows:

- **Full Trace Mode**
- **Real-Time Mode**

■ Setting MCU Operation Mode

There are two operation modes: the full trace mode, and the real-time mode. These modes are set using the [Setup] - [Debug environment] - [Debug environment] menu or the SET RUNMODE command of the instruction window.

● Full Trace Mode

In full trace mode, execution of all the instructions can be traced with no trace data missed. However, when branching has been performed for three times or more within 11 cycles, getting the trace data will be given a higher priority, as waits are inserted for MCU, it may not run in real time.

● Real time Mode

In real time mode, execution can be performed in the real time of a program. However, when branching has been performed for three times or more within 11 cycles, some of the trace data may be missed.

In addition, an error may occur during measurement of the cycle count.

2.5.1.4 Operation Frequency Control

This section describes the operation frequency setup.

■ Operation frequency

Set the operation frequency of MCU. Set the operation frequency using a value between 1 and 266MHz, inclusive. This setting optimizes the communication speed between MCU and emulator.

This function can be set using the [Setup] - [Debugging Environment] - [Debugging Environment] - [Frequency] menu or the SET FREQUENCY command.

Notes:

- This setting sets the maximum frequency and will not change the actual operation frequency.
- When a value smaller than the operation frequency is actually used, the emulator may malfunction.

2.5.2 Notes on Commands for Executing Program

When using commands to execute a program, there are several points to note.

■ Notes on GO Command

For the GO command, two breakpoints that are valid only while executing commands can be set. However, care is required in setting these breakpoints.

● Invalid Breakpoints

- No break occurs when a breakpoint is set at the instruction immediately after the following instructions.

F^2MC-16FX	PCB	DTB
	NCC	ADB
	SPB	CNR
	MOV ILM,#imm8	AND CCR,#imm8
	OR CCR,#imm8	POPW PS

- No break occurs when breakpoint set at address other than starting address of instruction.

■ Notes on STEP Command

● Exceptional Step Execution

When executing the instructions listed in the notes on the GO command as invalid breakpoints, such instructions and the next instruction are executed as a single instruction. Furthermore, if such instructions are continuous, then all these continuous instructions and the next instruction are executed as a single instruction.

● Step Execution that won't Break

Note that no break occurs after step operation when both the following conditions are met at one time.

- When step instruction longer than 2 bytes length and last code ends at even address
- When breakpoint already set at last address

  (This "already-set" breakpoint is an invalid breakpoint that won't break, because it has been set at an address other than the starting address of an instruction.)

■ Controlling Watchdog Timer

It is possible to select "The watchdog timer is stopped in the break. " while executing a program using the GO, STEP, CALL commands.

Use the ENABLE WATCHDOG, DISABLE WATCHDOG commands to control the watchdog timer.

- ENABLE WATCHDOG --- Enables the watchdog time during break.
- DISABLE WATCHDOG --- The watchdog timer is stopped in the break.

The start-up default in this program is "Enables the watchdog time during break".

[Example]

```
>DISABLE WATCHDOG
>GO
```

2.5.3 Commands Available during Execution of User Program

This section explains the commands available during the execution of a user program.

■ Commands Available during Execution of User Program

This emulator debugger allows you to use certain commands during the execution of a user program.

For more details, see "■ Debugger" in "SOFTUNE Workbench Command Reference Manual".

The double circle indicates that it is available during the execution of a user program.

Table 2.5-1 shows the commands available during the execution of a user program.

Besides, when the real-time monitor function is used, the specified memory area will be displayed in the real-time memory window, and data can be read (updated) even during MCU execution.

Table 2.5-1 Commands Available during Execution of User Program

Function	Restrictions	Major Commands
MCU reset	-	1.3 RESET
Displaying MCU execution status	-	2.12 SHOW STATUS
Displaying execution cycle measurement value (cycle)	-	4.27 SHOW TIMER
Memory operation (Read/Write)	-	5.1 EXAMINE, 5.2 ENTER, 5.3 SET MEMORY, 5.4 SHOW MEMORY, 5.5 SEARCH MEMORY, 5.8 COMPARE, 5.9 FILL, 5.10 MOVE, 5.11DUMP
Line assembly, Disassembly	-	6.1 ASSEMBLE, 6.2 DISASSEMBLE
Set breakpoints	Operable while the "Breakpoint Settings during Execution" is enabled in the execution tab of the debug environment dialog*	3.1 SET BREAK (type 1), 3.2 SET BREAK (type 2), 3.3 SET BREAK (type 3), 3.6 CANCEL BREAK, 3.7 ENABLE BREAK, 3.8 DISABLE BREAK, 3.9 SET DATABREAK (type 1), 3.10 SET DATABREAK (type 2), 3.12 CANCEL DATABREAK, 3.13 ENABLE DATABREAK, 3.14 DISABLE DATABREAK

*: For further details, refer to Section "2.5.4 Break".

Notes:

- The conditions which allow you to use the commands in Table 2.5-1 are limited to the following cases when a user program is executed.
  - [Debug] - [Run] - [Go] menu
  - [Go] button on the debug toolbar

  The commands in Table 2.5-1 cannot be used when the GO command is entered in the command window.
- An error message appears if you enter a command that cannot be used during the execution of a user program.

  "E4404S Command error (MCU is busy)."
- In Table 2.5-1, the commands of the memory operation and line assembly/disassembly are read/write when the CPU is temporarily stopped while the programs are being executed.

2.5.4 Break

In this emulator debugger, seven kinds of break functions can be used. When the program execution is aborted by each break function, the address and the break factor to do the break are displayed.

■ Break Functions

In this emulator debugger, seven kinds of break functions are supported.

- Code break
- Data break
- Guarded access break
- Trace-buffer-full break
- Performance-buffer-full break
- External trigger break
- Forced break

2.5.4.1 Code Break

This function aborts a program by monitoring the specified address using hardware or software. Break occurs prior to execution of the instruction of the specified address.

■ Code Break

This function aborts a program by monitoring the specified address using hardware or software. Break occurs prior to execution of the instruction of the specified address.

The maximum setting number is as follows:

Hardware : 4 points
Software : 2048 points

When a break occurs due to a code break, the following message is displayed on the Status Bar.

- Hardware
  Break at Address by hardware breakpoint
- Software
  Break at Address by breakpoint

■ Setting Method

The code break is controlled by the following method.

- Command
  - SET BREAK/HARD (Hardware)
  - SET BREAK/SOFT (Software)

Refer to "3.1 SET BREAK (type 1)" in "SOFTUNE Workbench Command Reference Manual".

- Dialog
  - Breakpoints set dialog [Code] tab
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".
- Window
  - Source window/Disassembly window

Notes:

- Hardware

  There are the following considerations for the hardware break.

  - Due to combination use with the sequencer or the trace trigger, the maximum setting number varies.
  - Do not set the hardware break to the instruction located in the delay slot. If such a setting is performed, branching will not be performed in spite of re-execution after break.
  - Make sure that the breakpoint must include the starting address of an instruction. Break may not occur.
  - When execution is performed starting from the address where the hardware break was set, if the preceding execution has been stopped due to reasons other than instruction break, break will occur without execution of the instruction. In such a case, when re-execution is performed, the instruction will be executed.

- Software

  There are the following considerations for the software break.

  - Setting cannot be performed in areas, such as ROM, where write cannot be correctly performed. In such cases, a verify error will occur when a program starts to be executed (when continuous execution or step execution is started).
  - Be sure to set the breakpoint in the starting address of an instruction. If the breakpoint is set in the middle of an instruction, the program may run away.

2.5.4.2 Data Break

It is a function to abort the program execution when the data access (read and write) is done to a specified address.

■ Data Break

It is a function to abort the program execution when the data access (read and write) is done to a specified address.

When a break occurs due to a data break, the following message is displayed on the Status Bar.

Break at Address by databreak at Access address

■ Setting Method

The data break is controlled by the following method.

- Command
  - SET DATABREAK
    Refer to "3.9 SET DATABREAK (type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Breakpoint Set Dialog [Data] tab
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".

Notes:

- Due to combination use with the sequencer or trace trigger, the maximum setting number varies.
- Word access from an odd address is performed using the byte access for twice (in terms of bus access). Note that this is the reason why even when word access from an odd address is specified, there will not be any hits.

2.5.4.3 Guarded Access Break

This function aborts the program execution when access has been performed using the specified attribute for the specified area.

■ Guarded Access Break

For the specified area, when the specified access attribute is found during execution of a user program, guarded access break will occur.

Guarded access can be specified with the following 3 types of attributes:

Code guarded

Break will occur when an instruction is executed for the specified area

Read guarded

Break will occur when read is performed for the specified area

Write guarded

Break will occur when write is performed for the specified area

If a guarded access occurs while executing a program, the following message is displayed on the Status Bar and the program is aborted.

Break at Address by guarded access {code/read/write} at Access address

■ Setting Method

The guarded access break is controlled by the following method.

- Command
  - SET GUARDMAP
    Refer to "1.48 SET GUARDMAP" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Map set dialog
    Refer to "4.7.3 Memory Map" in "SOFTUNE Workbench Operation Manual".

2.5.4.4 Sequential Break

A sequential break is a function to abort an executing program as event sequential control, when the sequential conditions are established.

■ Sequential Break

It is a function to abort the program execution by the sequential control of the event, when the sequential conditions are established. For details of the sequential control, refer to Section "2.5.5 Control by Sequencer".

When a break occurs due to a sequential break, the following message is displayed.

Break at Address by sequential break (level = Level No.)

■ Types of Sequential Break

This debugger has the following two types of the sequential breaks.

● 8 level sequence

8 level sequence is set in the sequence window displayed in [View]-[Sequence] menu. This sequence has the following features.

- Up to 8 levels can be set.
- Multiple level of the shift ahead can be set to one (shift ahead) event.
- The break or trace control (acquisition start/acquisition end) can be set when the sequencer is ended (END). The break is selected at this time.
- The trace control (acquisition start/acquisition end) can be set at each event hit of the sequencer.
- The current sequence level shift state at break can be displayed.

● 3 level sequence

3 level sequence is set in the 3 level sequence setting dialog displayed in [Debug]-[3 level sequence] menu. For details, refer to section "4.6.6 Sequence" in "SOFTUNE Workbench Operation Manual".

- Up to 3 levels can be set.
- One level of the shift ahead can be set to one (shift ahead) event.
- The break or trace control (acquisition start/acquisition end) can be set when the sequencer is ended (END). The break is selected at this time.
- When 3 level sequence is displayed in the sequence window, the current sequence level shift state at break can be displayed.

Note:

The last level number of the sequencer is always 7. Therefore, if the level number of the message displayed in the status bar at the sequential break is either 8 or 3 level, 7 is displayed in the last level number of the sequencer.

2.5.4.5 Trace-Buffer-Full Break

It is a function to abort the program execution when the trace buffer becomes full.

■ Trace-Buffer-Full Break

It is a function to abort the program execution when the trace buffer becomes full.

When a break occurs due to a trace-buffer-full break, the following message is displayed on the Status Bar.

Break at Address by trace buffer full

■ Setting Method

The trace-buffer-full break is controlled by the following method.

- Command
  - SET TRACE/BREAK
    Refer to "4.30 SET TRACE (type 2)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Trace Set Dialog
    Refer to "4.4.8 Trace" in "SOFTUNE Workbench Operation Manual".

2.5.4.6 Performance-Buffer-Full Break

It is a function to abort the program execution when the buffer for the performance measurement data storage becomes full.

■ Performance-Buffer-Full Break

It is a function to abort the program execution when the buffer for the performance measurement data storage becomes full.

When a break occurs due to a performance-buffer-full break, the following message is displayed on the Status Bar.

Break at Address by performance buffer full

■ Setting Method

The performance-buffer-full break is controlled by the following method.

- Command
  - SET PERFORMANCE/BREAK
    Refer to "4.8 SET PERFORMANCE (type 2)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Performance set dialog
    Refer to "4.4.13 Performance" in "SOFTUNE Workbench Operation Manual".

2.5.4.7 External Trigger Break

It is a function to abort the execution of the program when an external signal is input from TRIG pin that the emulator has.

■ External Trigger Break

It is a function to abort the execution of the program when an external signal is input from TRIG pin that the emulator has.

When a break occurs due to an external trigger break, the following message is displayed on the Status Bar.

Break at Address by external trigger break

■ Setting Method

The external trigger break is controlled by the following method.

- Command
  - SET TRIGGER
    Refer to "3.42 SET TRIGGER" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Debugging environment set dialog [emulation]tab
    Refer to "4.7.2.3 Debug Environment" in "SOFTUNE Workbench Operation Manual".

2.5.4.8 Forced Break

It is a function to abort the execution of the program compulsorily.

■ Forced Break

It is a function to abort the execution of the program compulsorily.

When a break occurs due to a forced break, the following message is displayed on the Status Bar.

Break at Address by command abort request

Note:

A forced break is not allowed while the MCU is in the low-power consumption mode or hold state. When a forced break is requested by the [Debug] - [Abort] menu while executing a program, the menu is disregarded if the MCU is in the low-power consumption mode or hold state. If a break must occur, then reset the cause at user system side, or reset the cause by using the [Debug] - [Reset MCU]menu, after inputting the [Debug] - [Abort] menu.

When the MCU enters the power-save consumption mode or hold state while executing, the status is displayed on the Status Bar.

2.5.5 Control by Sequencer

This emulator has a sequencer to control events. By using this sequencer, sampling of breaks or traces can be controlled while monitoring program flow (sequence). A break caused by this function is called a sequential break.

■ Control by Sequencer

As shown in Table 2.5-2, controls can be made at 8 different levels.

One event can be set for one level.

The sequencer can perform shift from any level to any level, and the restart conditions can also be specified.

Table 2.5-2 Sequencer Specifications

Function	Specifications
Level count	8 level
Conditions settable for each level	1 event conditions (1 to 65535 times pass count can be specified for each condition.)
Restart conditions	1 event conditions (1 to 65535 times pass count can be specified.)
Operations after shift	Break, trace control (start/end)

■ Setting Events

The emulator can monitor the MCU bus operation, and generate a trigger for a sequencer at a specified condition. This function is called an event.

In the event, code (/CODE) and data access (/READ/WRITE) can be specified.

Up to eight events can be set. However, since hardware is shared with trace triggers, the actual numbers is calculated as follows.

Current maximum constant of events =
8 - (current number of break settings + current number of trace trigger settings)

Table 2.5-3 shows the conditions that can be set for events.

Table 2.5-3 Conditions for Event and Trace Trigger

Condition	Description
Address	Memory location (address bit masking disabled)
Data	16-bit data (data bit masking enabled)
Access size	Byte, word
Access attribute	Code/Data read/Data write
Bus master	CPU, DMA

The sequence event is setting by the following command.

- SET SEQUENCE :Sets sequence event
- SHOW SEQUENCE :Displays sequence event status
- CANCEL SEQUENCE :Deletes event

Notes:

- In instruction execution (/CODE), an event trigger is generated only when an instruction is executed. This cannot be specified concurrently with other status (/READ or /WRITE).
- In the case of data event, word access from an odd address (in terms of bus access) is performed using a byte access for twice . Note that this is the reason why even when word access from an odd address is specified there is nothing found.

2.5.5.1 Operating of sequencer

The sequencer works in the following order.
1) The sequencer starts when the program execution begins.
2) It diverges to the level the shift ahead when the condition consists by setting each level.
3) When the restart condition consists, the sequencer is begun again.
4) When the condition that the level becomes END the shift ahead consists, the sequencer ends and the break is done.

■ Operating of Sequencer

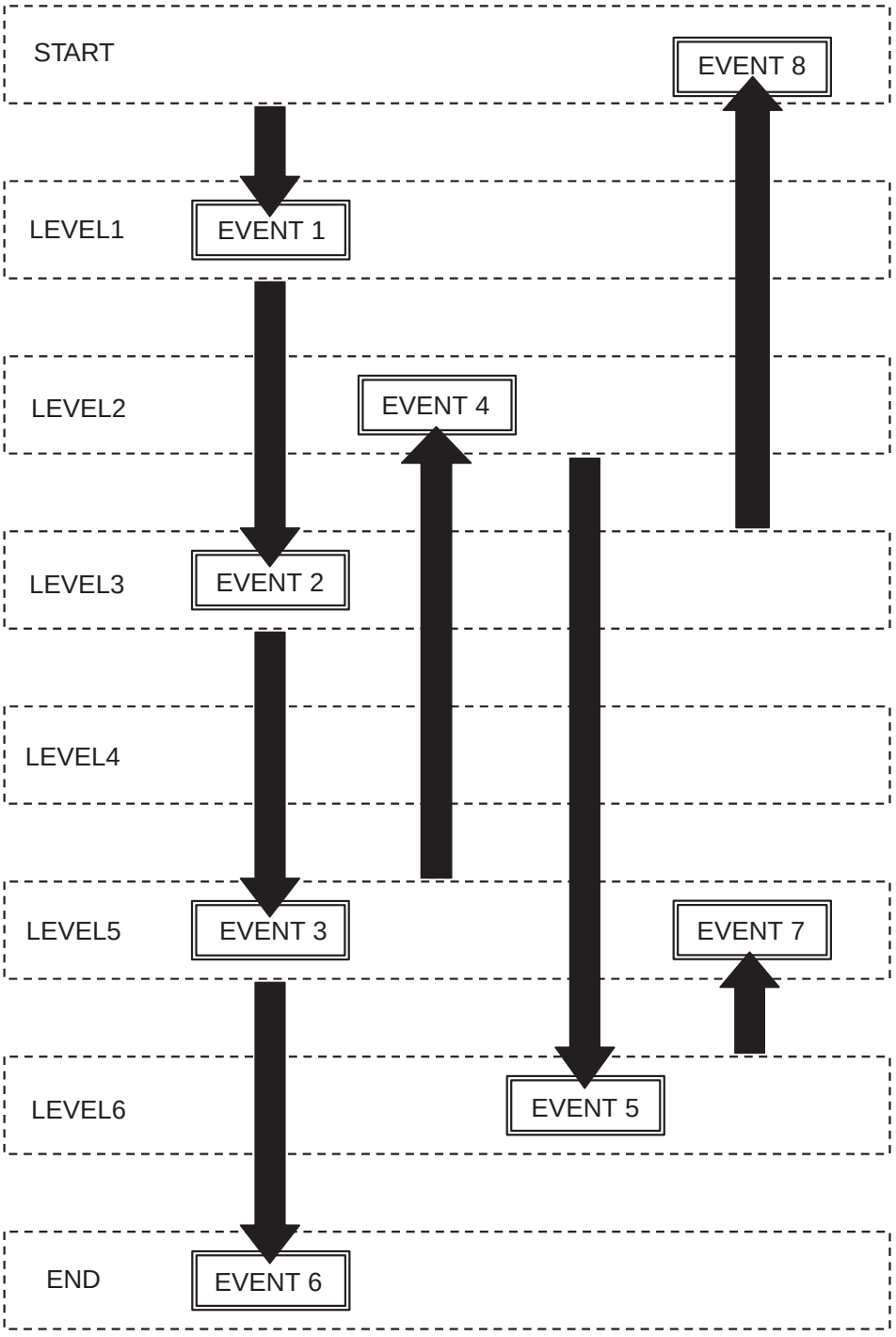
The sequencer works in the following order. The event can be set as each level and a restart condition.

1) The sequencer starts when the program execution begins.
2) It diverges to the level the shift ahead when the condition consists by setting each level.
3) When the restart condition consists, the sequencer is begun again.
4) When the condition that the level becomes END the shift ahead consists, the sequencer ends and the break is done.

Note:

When the level the shift ahead has been END, re-execution of the user program will restart the sequencer.

Figure 2.5-1 Operation of Sequencer



2.5.6 Real-time Trace

While execution a program, the address, data and status information, and the data sampled by an external probe can be sampled in machine cycle units and stored in the trace buffer. This function is called real-time trace.
In-depth analysis of a program execution history can be performed using the data recorded by real-time trace.

■ Trace Buffer

The data recorded by sampling in machine cycle units, is called a frame.

The trace buffer can store 64K frames (65536). When the enhancing trace board is used, it becomes capacity for 256M (268,435,456) frame.

Since the trace buffer has a ring structure, when it becomes full, it automatically returns to the start to overwrite existing data.

■ Trace Data

Data sampled by the trace function is called trace data.

The following data is sampled:

- Branching instruction frame
  Branching source address, branching target address, disassemble
- Data frame
  Access address, Access data, Access size, Access attribute (read/write), and Bus master (CPU/DMA)
- Special frame
  Program stop, Trace start/end, Reset, Loop count, Extended time stamp frame, Data lost
- Difference of execution time with frame immediately before (unit of CPU clock)

■ Frame Number

A number is assigned to each frame of sampled trace data. This number is called a frame number.

The frame number is used to specify the display start position of the trace buffer. The value 0 is assigned to trace data at the triggering position for sequencer termination. Negative values are assigned to trace data that have been sampled before arrival at the triggering position (See Figure 2.5-2).

If there is no triggering position for sequencer termination, the value 0 is assigned to the last-sampled trace data.

Figure 2.5-2 Frame Number at Tracing

■ Trace Filter

To make effective use of the limited trace buffer capacity, in addition to the code fetch function, a trace filter function is incorporated to provide a means of acquiring information about data accesses to a specific region.

The following value can be specified in the data trace filter function.

- Access attribute (read/write)
- Data trace start address/end address

Moreover, the function to compress into one frame when the same frame is repeated is provided, too.

■ Trace Trigger Setup

When preselected conditions are met during MCU bus operation monitoring, a trigger for starting a trace can be generated. This function is called a trace trigger.

For the use of the trace trigger function, specify the code (/CODE) and data access (/READ/WRITE).

Up to 4 trace triggers can be preset each for code attribute and data access attribute. However, actually, the maximum number of trace triggers is determined as indicated below because the common hardware is used with events.

Current trace trigger maximum constant = 4 - (current break count setting + current event count setting)

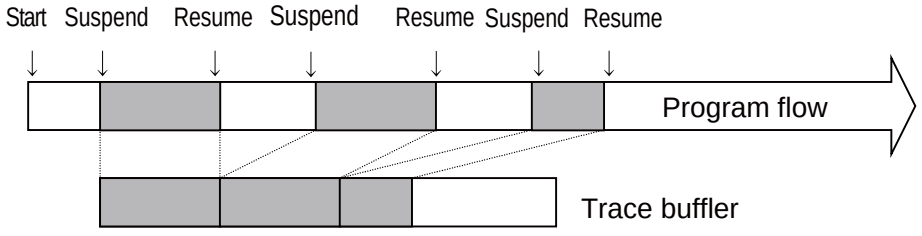
For the trace trigger setup conditions that can be defined, see Table 2.5-2.

For trace trigger setup, use the following commands:

- SET TRACETRIGGER : Sets trace trigger
- CANCEL TRACETRIGGER : Deletes trace trigger
- SHOW TRACETRIGGER : Displays trace trigger setting status
- SHOW TRACE/STATUS : Displays Trace setup status

Figure 2.5-3 shows a trace sampling operation.

Figure 2.5-3 Trace Sampling Operation (Trace Trigger)



2.5.6.1 Setting Trace

To perform a trace, follow steps (1) to (3) below. When a program is executed after completion of the following steps, trace data is sampled.

(1) Enable the trace function.

(2) The event and the sequencer are set.

(3) Perform trace buffer full break setup.

■ Setting Trace

To perform a trace, complete the following setup steps. When a program is executed after completion of the steps, trace data is sampled.

1) Enable the trace function.

Enable the trace function using the ENABLE TRACE command.

To disable the trace function, use the DISABLE TRACE command.

The trace function is enabled by default when the program is launched.

2) Set up the event and the sequencer.

Use of the trace trigger allows control of the trace sampling, making full use of the limited-size trace buffer. Such setups should be performed on a necessary base.

The trace trigger can specify the start/stop of trace sampling with the trigger hit as the reason.

When the trace trigger is used, setup is performed by inputting the SET TRACE/TRIGGER command.

3) Perform trace buffer full break setup.

A break can be invoked when the trace buffer becomes full.

To perform setup, use the SET TRACE command. This break feature is disabled when the program starts. To view the setting, use SHOW TRACE/STATUS.

Table 2.5-4 shows trace related commands in single trace.

Table 2.5-4 Trace Related Commands in Single Trace

Available command	Function
SET TRACETRIGGER	Sets up the trace trigger
CANCEL TRACETRIGGER	Deletes the trace trigger
SHOW TRACETRIGGER	Displays the trace trigger
SET TRACE	Sets trace buffer full break
SHOW TRACE	Displays trace data
SEARCH TRACE	Searches for trace data
ENABLE TRACE	Enables trace function
DISABLE TRACE	Disables trace function
CLEAR TRACE	Clears trace function

Note:

In the case of the data trace trigger, word access from an odd address (in terms of bus access) is performed using a byte access for twice. Note that this is the reason why there will not be any hits even when word access is specified from an odd address.

2.5.6.2 Displaying Trace Data Storage Status

It is possible to displays how much trace data is stored in the trace buffer. This status data can be read by specifying /STATUS to the SHOW TRACE command.

■ Displaying Trace Data Storage Status

It is possible to displays how much trace data is stored in the trace buffer. This status data can be read by specifying /STATUS to the SHOW TRACE.

[Example]

```
>SHOW TRACE/STATUS
en/dis      = enable        ; Trace function enabled
buffer full = nobreak       ; Buffer full break function disabled
code        = enable        ; Code execution enabled
loop compress = enable      ; loop compress function enabled
frame no. = -00120 to 00000 ; Frame -120 to 0 store data
>
```

2.5.6.3 Specifying Displaying Trace Data Start

The data display start position in the trace buffer can be specified by inputting a step number or frame number using the SHOW TRACE command. The data display range can also be specified.

■ Specifying Displaying Trace Data Start

Specify the data display start position in the trace buffer by inputting a step number or frame number using the SHOW TRACE command. The data display range can also be specified.

[Example]

```
>SHOW TRACE/RAWDATA -6      ; Start displaying from frame -6
>SHOW TRACE/RAWDATA -6..0   ; Display from frame -6 to frame 0
>SHOW TRACE -6              ; Start displaying from step -6
>SHOW TRACE -6..0           ; Displays from step -6 to step 0
```

2.5.6.4 Display Format of Trace Data

The trace data display format can be selected by running the SHOW TRACE command with a command modifier specified. If setup is completed with the SET SOURCE command so as to select a source line addition mode, a source line is attached to the displayed trace data.

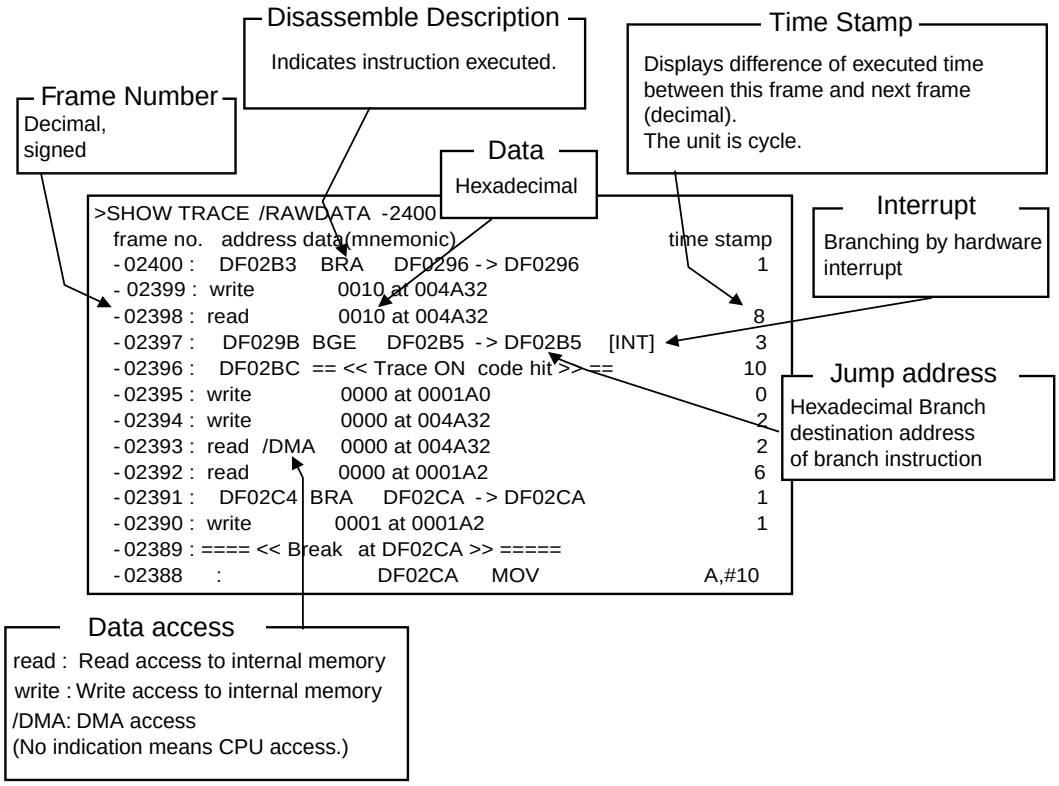
There are three formats to display trace data:

- **Display without analyzing trace data (Specify /RAWDATA.)**
- **Display in instruction execution order (Specify /INSTRUCTION.)**
- **Display in source line units (Specify /SOURCE.)**

■ Display without Analyzing Trace Data (Specify /RAWDATA.)

The frame output by the emulator is not analyzed and it displays it as it is.

The display of the source is done and corked in this mode regardless of the setting by the SET SOURCE command.



Special frame is as follows.

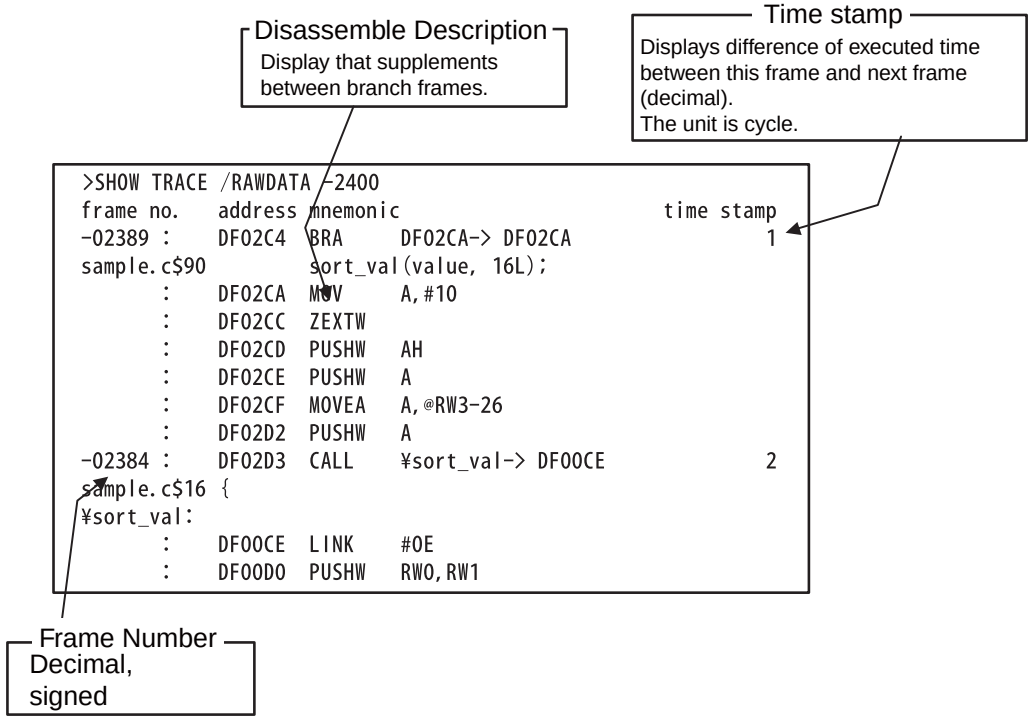
Break at "address":	Displays address which program execution is stopped.
Trace ON code(data) hit:	Indicates that trace acquisition is started.
Trace OFF code(data) hit:	Indicates that trace acquisition is stopped.

Reset:	Indicates that reset is detected.
Loop Count "Number of times":	Displays number of times which loop count occurs.
Extended time stamp frame:	Displays here when the value of time stamp is 8191 or more.
Data Lost Error:	Indicates that data is lost.

■ Display in Instruction Execution Order (Specify /INSTRUCTION.)

It is a form that is pulled out the divergence frame from the RAW data display, and supplemented between frames with the reverse-assembly display. Special frames other than the program lockup frame are displayed.

The display in this mode is as follows.



Special frame is as follows.

Trace ON code(data) hit:	Indicates that trace acquisition is started.
Trace OFF code(data) hit:	Indicates that trace acquisition is stopped.
Reset:	Indicates that reset is detected.
Loop Count "Number of times":	Displays number of times which loop count occurs.
Extended time stamp frame:	Displays here when the value of time stamp is 8191 or more.
Data Lost Error:	Indicates that data is lost.

■ Display in Source Line Units (Specify /SOURCE.)

Only the source line can be displayed.

[Example]

```
>SHOW TRACE/SOURCE -1010..-86
step no.  source
-01007    : sample.c$68            value [i] = &target[I];
-00905    : sample.c$68            value [i] = &target[I];
-00803    : sample.c$68            value [i] = &target[I];
-00698    : sample.c$70    sort_val(value, 16L);
-00655    : sample.c$9 {
-00594    : sample.c$13    for (k = max / 2; k >= 1; k--){
-00185    : sample.c$14              i = k;
-00149    : sample.c$15              p = tblp[i - 1];
-00088    : sample.c$16              while ((j = 2 * i) <= max){
```

2.5.6.5 Saving Trace Data

This section explains how to save trace data.

■ Saving Trace Data

Trace data can be saved in a specified file.

The following two methods are available to save trace data: using GUI (window or dialog) and using only the command. The same result is obtained from both methods.

● Using GUI for Saving Trace Data

1. Display the trace window.
   - Select [View] - [Trace] menu.
2. Specify the name of the file in which to save trace data.
   - Right-click on the trace window, and select [Save] from the shortcut menu. The [Save as] dialog appears.
     Specify the file name and where to save trace data. For details, refer to Section "4.4.8 Trace" in "SOFTUNE Workbench Operation Manual".

● Using Command for Saving Trace Data

1. Save trace data.
   - Execute the SHOW TRACE/FILE command.
     For details, refer to Section "4.33 SHOW TRACE (type 3)" in "SOFTUNE Workbench Command Reference Manual".
     When additionally saving trace data in an existing file, execute the SHOW TRACE/FILE/APPEND command.

2.5.7 Measuring Performance

It is possible to measure the time and pass count between two events. Repetitive measurement can be performed while executing a program in real-time, and when done, the data can be totaled and displayed.
Using this function enables the performance of a program to be measured.

■ Performance Measurement Function

The performance measurement allows the time between two event occurrences to be measured and the number of event occurrences to be counted. Up to 65535 event occurrences can be measured.

- Measuring Time

  Measures time interval between two events. Two sections can be set.

- Measuring Count

  The specified events become performance measurement points automatically, and occurrences of that event are counted.

2.5.7.1 Performance Measurement Procedures

Performance can be measured by the following procedure:

1. Setting minimum measurement unit for timer.
2. Specify performance-buffer-full break.
3. Setting events.
4. Executing program.
5. Displaying performance measurement data.
6. Clearing performance measurement data.

■ Setting Minimum Measurement Unit for Timer

It is 1ns as the minimum measurement unit for the timer used to measure performance. Moreover, the resolution of the measurement data depends on the clock of CPU.

■ Specifying Performance-Buffer-Full Break

When the buffer for storing performance measurement data becomes full, a executing program can be broken. This function is called the performance-buffer-full break. The performance buffer becomes full when an event occurs 65535 times.

If the performance-buffer-full break is not specified, the performance measurement ends, but the program does not break.

[Example]

```
>SET PERFORMANCE/NOBREAK     <--     Specifying Not Break
>
```

■ Setting Events

The event is set by event setting (performance section setting) dialog or SET PERFORMANCE command. Two sections can be set.

- Measuring Count

The specified events become performance measurement points automatically.

■ Executing Program

Start measuring when executing a program by using the GO or CALL command. If a break occurs during interval time measurement, the data for this specific interval is discarded.

■ Displaying Performance Measurement Data

Display performance measurement data by using the SHOW PERFORMANCE command.

■ Clearing Performance Measurement Data

Clear performance measurement data by using the CLEAR PERFORMANCE command.

[Example]

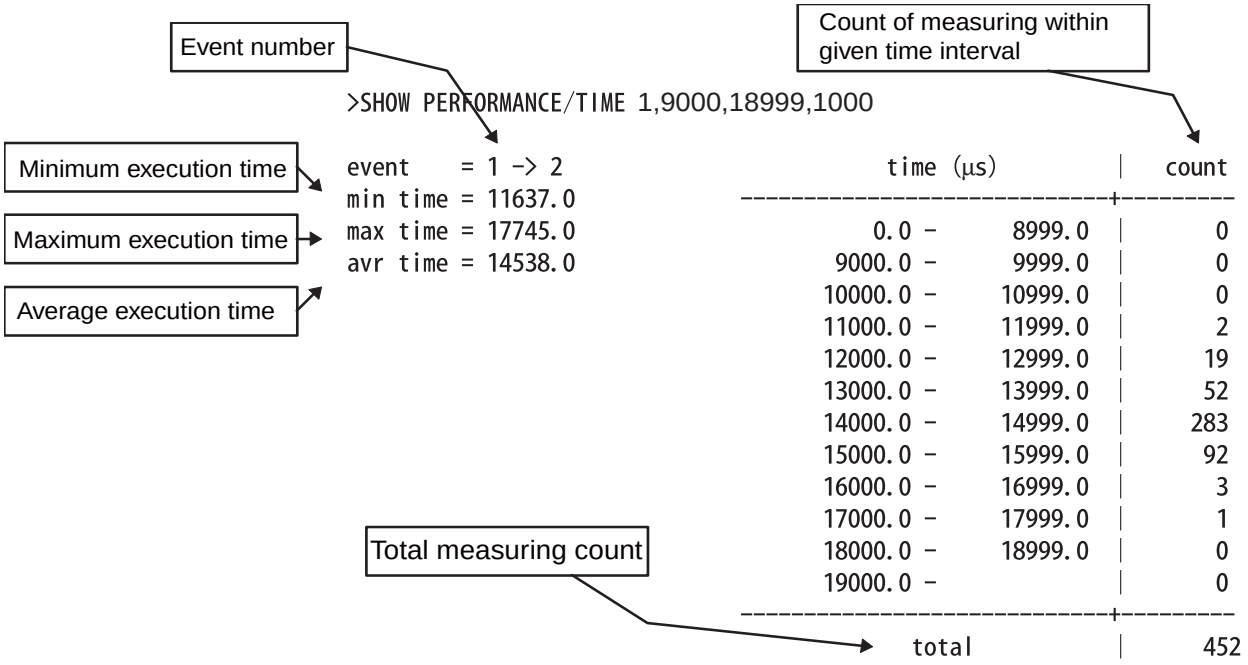
```
>CLEAR PERFORMANCE
>
```

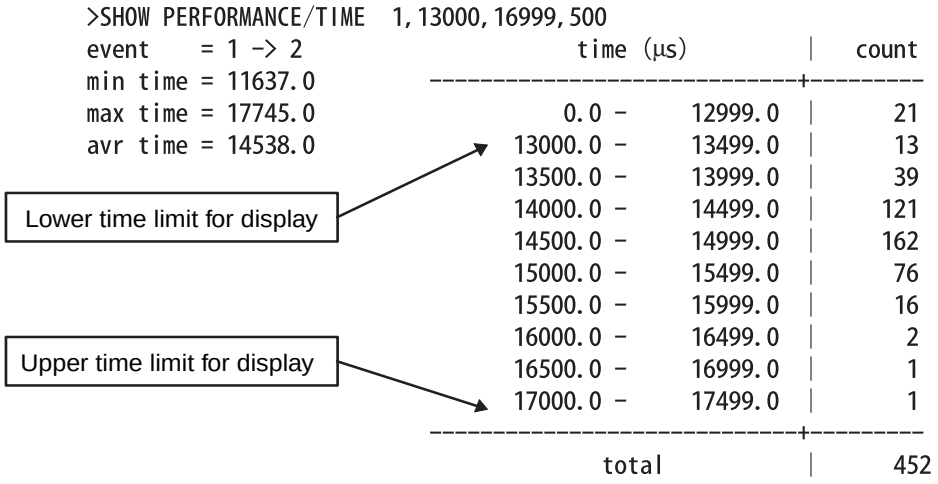
2.5.7.2 Display Performance Measurement Data

Display the measured time and measuring count by using the SHOW PERFORMANCE command.

■ Displaying Measured Time

To display the time measured, specify the starting event number or the ending event number.





2.5.8 Execution Time Measurement

This function measures the program execution time.

■ Measurement Items

Measures time between the start and stop of program execution.

In this emulator debugger, the measurement is performed by the emulation timer or cycle counter. The following shows the features.

- Emulation timer

  Resolution : 25 ns

  Significant bits: 64 bits

  Maximum measurement time : 18,446,744,073,709,551,615 x 25 ns
- Cycle counter

  Significant bits: 64 bits

  Maximum measurement cycle count : 18,446,744,073,709,551,615 cycles

In either case, the measurement is performed whenever a program is executed, and the measurement result displays the following two values:

- Number of cycles spent on the previous program execution
- Total number of cycles executed since the previous clearing

■ Displaying Measurement Results

Either of the following methods can be used to display the measurement results.

- Display by dialog

  The results appear in the time measurement dialog, which can be displayed by selecting [Debug] - [Time Measurement] menu.

  For details, refer to Section "4.6.8 Time Measurement" in "SOFTUNE Workbench Operation Manual".
- Display by command

  Enter the SHOW TIMER command in the command window.

  For details, refer to Section "4.27 SHOW TIMER" in "SOFTUNE Workbench Command Reference Manual".

■ Clearing Measurement Results

Either of the following methods can be used to clear the measurement results.

- Clearing by dialog

  Click the [Clear] button in the time measurement dialog, which can be displayed by selecting [Debug] - [Time Measurement] menu.

  For details, refer to Section "4.6.8 Time Measurement" in "SOFTUNE Workbench Operation Manual".
- Clearing by command

  Enter the CLEAR TIMER command in the command window.

  For details, refer to Section "4.28 CLEAR TIMER" in "SOFTUNE Workbench Command Reference Manual".

Note:

The measured execution time is added about ten extra cycles per execution. If the execution cycle is measured, execute many instructions continuously in order to minimize the effect of error.

2.5.9 Power-On Debugging

This section explains power-on debugging by the emulators for the MB2198.

■ Power-on Debugging

Power-ON debugging refers to the operation to debug the operating sequence that begins when the power to the target is switched on.

For products with a dedicated power-on debugging terminal, the MB2198 emulator can debug the sequence performed immediately after power-on. The following functions are available:

- Code break
- Data break
- Sequencer
- Trace trigger
- Trace measurement
- Coverage measurement

The power-on debugging procedure is described below:

- Set the DIP switch on the adapter board mounted in the upper part of the emulator.
- Turn on the target board and emulator main unit.
- Launch Workbench to start debugging.

  For debugging, set hardware breaks, etc.
- To start a power-on debugging, run [Execute] - [Power-ON Debug] menu.

  Input the lower limit value of the monitoring voltage from the [User Power Monitor Voltage] dialog box to display PON in the input status bar.]
- Run the program.
- Turn the target board off while running and then back on.
- Conduct debugging.
- To terminate the power-on debugging, run [Execute] - [Power-ON Debug] menu.

2.6 Emulator Debugger (MB2100-01)

This section describes the emulator debugger functions that are available when the MB2100-01 is specified.

■ Features of Emulator Debugger for MB2100-01

The emulator debugger for MB2100-01 has the following features:

● Real-time control

The following operations can be controlled during the execution of the user program:

- Manipulation of memory content (reading/writing, search, comparison, filling, transfer)
- Setting/cancellation of events
- Setting/cancellation of trace mode

● FLASH support

Similar to the RAM area, data can be downloaded to FLASH memory as well as read/written from the memory window.

● Multifunctional events

Events can be used in the following six functions:

- Code break (hardware)
- Code break (hardware/count)
- Data break
- Data watch break
- Sequence
- Performance trigger

The number of points that can be set varies depending on the function and model.

● Inhibiting transition to standby mode

This function inhibits the transition to the standby mode before it is attempted when starting the debugger.

2.6.1 Starting debugging

This section describes the method of starting debugging by with the use the MB2100-01 emulator debugger.

■ Starting Debugging

When starting debugging, select the [Debug] - [Start debug] menu. When debugging is started by a new project, the setup wizard for performing initial setting is activated. For details, refer to "4.7.2.5 Setup Wizard" in "SOFTUNE Workbench Operation Manual".

■ Verification Items When Starting Debugging

When starting debugging, perform checking for initial settings. When an item of initial setting is not correct, debugging cannot be started.

- Operating environments of the target

  Verify whether the operating environment of the target has a problem.

  For details, refer to "2.6.1.1 Operating Environments of the Target".

- Security

  Verify whether the security function has been enabled.

  For details, refer to "2.6.1.2 Security".

2.6.1.1 Operating Environments of the Target

This section describes the setting of the target operating environments of the MB2100-01 emulator debugger.

■ Operating Environments of the Target

In this emulator debugger, it is necessary to set the following items according to the operating environments of the target.

- Source oscillation frequency
- Length of DEBUG I/F cable

These settings influence the communication speed of the debugger.

● Source oscillation frequency

Set main clock (MCLK).

The communication speed between MB2100-01 and the user system varies depending on the main clock.

● Length of DEBUG I/F cable

Specified the length of the cable that suits the length of DEBUG I/F cable.

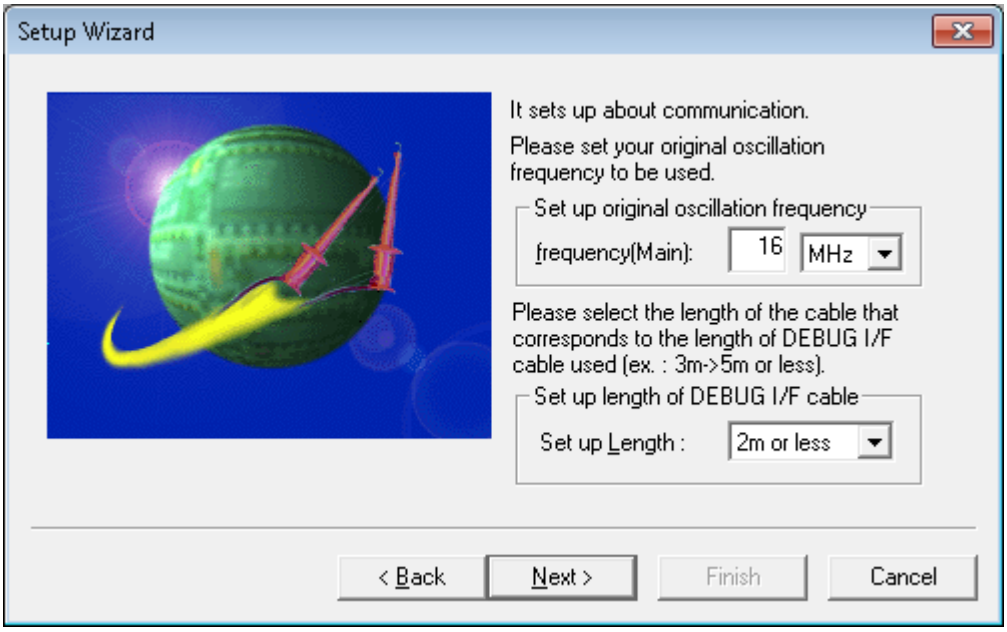
The allowance maximum transfer rate from MB2100-01 to the direction of MCU changes according to this length of the cable.

■ How to set

The setup wizard sets the operating environments of the target.

For details, refer to "4.7.2.5 Setup Wizard" in "SOFTUNE Workbench Operation Manual".

Figure 2.6-1 Setup Wizard (Communication Setting)



Notes:

- When the operating environment set by the setup wizard is different from the actual operating environment, the debugger cannot be activated.
- For details on the DEBUG I/F (interface), refer to "EMBEDDED EMULATOR MB2100-01-E OPERATION MANUAL".

2.6.1.2 Security

This section describes the security of the MB2100-01 emulator debugger.

■ Security

When beginning to debug it when the security function of target MCU is effective, it is necessary to enter the password in this emulator debugger.

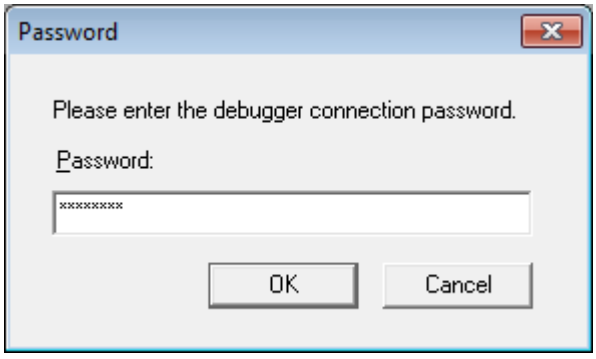
For the security function, refer to the hardware manual of model to be used.

■ How to enter

When a dialog shown below is displayed, enter a preset password. The password is needs to be entered each time the debugger is activated.

For details on the password, refer to the description of Password for "OCD (On Chip Debugger)" start permission in the hardware manual for the product used.

Figure 2.6-2 Debugger Connection Password



Note:

- When authentification of the password has failed, the debugger cannot be activated. Turn on again the power supply of the target to activate the debugger again.
- When the user system is in the bus sleep state, press the OK button after the bus sleep state is canceled.

2.6.2 Ending debugging

This section describes the method of ending debugging being executed with the use of the MB2100-01 emulator debugger.

■ Ending debugging

When ending debugging, select the [Debug] - [End debug] menu.

Turn off the power supply of the target after selecting the [End debug] menu.

■ When the debugger has aborted

When the debugger has aborted for some reason, problems as described below can occur. When starting debugging again, take corresponding countermeasures.

- The code of a software break remains on the flash memory

  When a software break is set in a flash memory area, the contents of the flash memory are rewritten with the code of the software break. When debugging has ended normally, the re-written data is reverted. If it has ended abnormally, software break code may remain without data being reverted.

  When starting the debugger, it checks whether this software break exists. If it does, the following message appears.

  "The software break set in A on B might remain."

  A: A project name displayed when the debugger aborted

  B: The date when the debugger aborted

  When the message is displayed, download again the program to the flash memory.

- The DEBUG I/F enters the pull-up state.

  When the debugger has aborted, the DEBUG I/F enters the pull-up state. When starting debugging again, ensure that the power supply of MB2100-01 is turned on again.

Note:

A warning message related to a software break is displayed even when a project other than the project name displayed in the message is used.

After a software breakpoint was deleted, a warning message may be displayed even if the debugger was ended abnormally while using another debug function.

2.6.3 Efficiently Executing Debugging

This section describes setting for efficient debugging.

■ Setting Operating Environment

In order to enable the user to even more comfortably execute debugging, the emulator debugger provides the following items required to be set correspondingly to, for example, the operating environment and the usage.

- Standard clock frequency for high-speed communication
- Debug function

Therefore, if the default value is used as it is, there is no need to change this setting. In addition, a set value once specified is set as a default for the subsequent operation.

2.6.3.1 Increasing Communication Speed during Debugging

This section describes setting for increasing the communication speed during debugging.

■ Standard Clock Frequency for High-speed Communication

In the case of this emulator debugger, when the standard clock frequency for high-speed communication is set to the optimal value, the phase modulation mode is enabled, and high-speed communication can be performed between the target and adapter. The standard clock frequency for high-speed communication is different in optimal value depending on the MCU. For details, refer to the hardware manual of model to be used.

■ How to set

The method of setting the standard clock frequency for high-speed communication is described below.

- Setting by dialog

  Select the [Setup] - [Debug environment] - [Debug environment] menu, and then select the [Frequency] tab.

  For details, refer to "4.7.2.3 Debug Environment" in "SOFTUNE Workbench Operation Manual".

- Setting by Command

  Execute the SET FREQUENCY command.

  For details, refer to "1.45 SET FREQUENCY" in "SOFTUNE Workbench Command Reference Manual".

Note:

If the frequency is changed during high-speed communication mode, the MCU must be reset. The frequency is changed after a reset is updated.

2.6.3.2 Switching Debug Function

This section describes the method of switching the debug function correspondingly to the usage.

■ Debug Functions

The emulator debugger allows the debug functions to be selectively used by effecting mode switching correspondingly to the usage.

The mode has two types described below.

- Execution time mode

  This mode selects the method of measuring the user-program execution time.

  - Time measurement mode (default)
    This mode measures the time from the start of execution to the break occurrence.
  - Performance mode
    This mode measures the time between specified two events (points).

- Pass count mode

  This mode selects the using method for the pass count function.

  - Sequential mode
    This mode uses the sequential function.
    The pass count break cannot be used.
  - Pass count break mode (default)
    This mode uses the pass count break.
    The sequential function cannot be used.

■ Switching methods

Methods of switching to the execution time mode and the pass count mode are described below.

● Dialog-used switching

Select the [Setup] - [Debug environment] - [Debug environment] menu, and then select the [Event] tab.

For details, refer to "4.7.2.3 Debug Environment" in "SOFTUNE Workbench Operation Manual".

● Command-used switching

Execute the SET MODE command.

For details, refer to "1.9 SET MODE (type 2)" in "SOFTUNE Workbench Command Reference Manual".

2.6.4 Executing Program

This section describes the method of executing a user program with the MB2100-01 emulator debugger.

■ Executing a program

A user program is executed in a procedure described below.

1. Open a project (workspace).
   Select the [File] - [Open workspace file] menu.
2. Start debugging.
   For details, refer to "2.6.1 Starting debugging".
3. Load an execution-desired target program.
   When loading a project target file, select the [Debug] - [Load target file] menu.
4. Execute program.
   Select the [Debug] - [Run] - [GO] menu.
   For other executions, such as step execution, refer to "4.6.1 Run" in "SOFTUNE Workbench Operation Manual".

■ Control during program execution

This emulator debugger is capable of controlling the following during the execution of a user program.

- Debug function setting/release
- Monitoring
- Power-on debug

2.6.4.1 Setting/Release of Debug Functions

The debug function can be set or released while executing the user program.

■ Commands Available during Execution of User Program

A specific debug feature can be set/released while executing the user program in this emulator debugger. Either the dialog or the command can be set/released.

Table 2.6-1 shows the commands available during execution of user program. For more details, see "● Debugger" in "SOFTUNE Workbench Command Reference Manual".

Table 2.6-1 Commands Available during Execution of User Program

Function	Major Command name*1
Reset MCU	1.3 RESET
Memory operation (read/write)	5.1 EXAMINE 5.2 ENTER 5.3 SET MEMORY 5.4 SHOW MEMORY 5.5 SEARCH MEMORY 5.8 COMPARE 5.9 FILL 5.10 MOVE 5.11 DUMP
Line assemble/disassemble	6.1 ASSEMBLE 6.2 DISASSEMBLE
Set/delete breakpoint	3.1 SET BREAK (type1) 3.3 SET BREAK (type3) 3.6 CANCEL BREAK 3.7 ENABLE BREAK 3.8 DISABLE BREAK 3.10 SET DATABREAK (type2) 3.12 CANCEL DATABREAK 3.13 ENABLE DATABREAK 3.14 DISABLE DATABREAK
Set/delete sequencer	3.22 SET EVENT(type 2) 3.24 CANCEL EVENT 3.25 ENABLE EVENT 3.26 DISABLE EVENT 3.27 SET SEQUENCE (type1) 3.34 CANCEL SEQUENCE(type 1) 3.36 ENABLE SEQUENCE(type 1) 3.38 DISABLE SEQUENCE(type 1)
Trace operation	4.15 CLEAR TRACE 4.17 ENABLE TRACE (type2) 4.19 DISABLE TRACE (type2) 4.20 SEARCH TRACE

*1 : Refer to "SOFTUNE Workbench Command Reference Manual".

Note:

An error message appears if you enter a command that cannot be used during the execution of a user program.

"E4404S Command error (MCU is busy)."

2.6.4.2 Monitoring

This section describes the monitoring function in the MB2100-01 emulator debugger.

■ Monitoring

The monitoring function is capable of real-time referencing a variation in the value of a specific address during user program execution.

The function is capable of a variation in the value of a specified watch variable, in addition to the value of a specific address.

■ How to use

The use procedure of the monitoring function is described below.

● When performing monitoring of the memory window

1. Display the memory window.
   - Select the [View] - [Memory] menu.
     Specify a target address for monitoring
2. Enable the monitoring function through any one of methods described below.
   - Select the shortcut menu [Monitoring] of the memory window.
   - Select the [Setup] - [Debug environment] - [Debug environment] menu to display the [Monitoring] tab.
3. Execute the program.

According to the above, a portion with variation during the program execution is displayed in red.

● When performing monitoring of the watch window

1. Display the watch window.
   - Select the [View] - [Watch] menu.
     Register a target watch variable for monitoring
     For details, refer to "4.4.7 Watch" in "SOFTUNE Workbench Operation Manual".
2. Enable the monitoring function through any one of methods described below.
   - Select the shortcut menu [Monitoring] in the memory window.
   - Select the [Setup] - [Debug environment] - [Debug environment] menu to display the [Monitoring] tab.
3. Execute the program.

According to the above, a portion with variation during the program execution is displayed in red.

2.6.4.3 Power-on Debug

This section describes power-on debug function in the MB2100-01 emulator debugger.

■ Power-on Debug

Power-on debug is a function to debug the sequence immediately after turning on of the power supply of the target system.

■ How to use

The use procedure of power-on debug is as follows:

● When power-on debug

1. Start debug.
   Select [Debug] - [Start debug] menu.
2. Power-on debug mode is made effective.
   Select [Debug] - [Run] - [Power on Debug] menu.
   It shifts to power-on debug mode.
3. Execute the user program.
   Continuous execution of the user program that doesn't do anything such as infinity looping is recommended.
   Display the confirmation dialog whether the program execution is interrupted.
4. Do either the following:
   - Chip reset is issued from the outside.
   - The power supply of the target is turned on again.

   After the power supply returns, the program starts running from the reset vector.

● When release power-on debug mode

Before executing the user program

Select [Debug] - [Run] - [Power on Debug] menu.

After executing the user program

Press the cancel button by the interruption dialog displayed in power-on debug mode.

Notes:

- Other debug features cannot be used while debugging power-on at all.
- When security is enabled, power on debug is not available.
- Selecting the power-on debug menu, the following functions cleared.
  - Performance measurement
  - Execution cycle measurement
- Turning on the power supply of the target again, the following functions cleared.
  - Performance measurement
  - Trace data
  - Data match status of Data watch break
  - Hit count of Sequence
  - Hit count of Passcount break

2.6.4.4 Notes on Commands for Executing Program

When using commands to execute a program, there are several points to note.

■ Notes on GO Command

For the GO command, two breakpoints that are valid only while executing commands can be set. However, care is required in setting these breakpoints.

● Invalid Breakpoints

- No break occurs when the breakpoint is set at three instructions or less executed continuously from the user interrupt.
- No break occurs when breakpoint set at address other than starting address of instruction.
- No break occurs when a breakpoint is set at three instructions or less immediately after the following instructions.

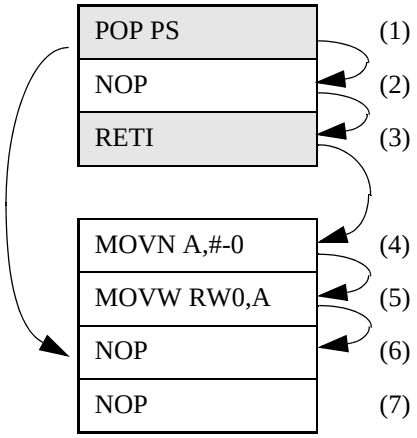
F^2MC-16FX	PCB NCC SPB MOV ILM,#imm8 OR CCR,#imm8 INT addr16 INT9 JCTX @A Undefined instruction	DTB ADB CNR AND CCR,#imm8 POPW PS INTP addr24 INT #vct RETI

■ Notes on STEP Command

● Exceptional Step Execution

When executing the instructions listed in the notes on the GO command as invalid breakpoints, such an instruction and next three instructions are executed as a single instruction.
Furthermore, when above-mentioned instructions are included in the next continuous instructions, all of them and the next continuous three instructions or less are executed as a single instruction.

[Example] When instructions as invalid breakpoints is consecutive



Because "POP PS" (1) is an instruction as invalid breakpoint shown in "Notes on GO Command", no break occurs at three instructions following "POP PS".

And because instruction (3) is the instruction shown in above-mentioned note among three instructions (2), (3) and (4) following "POP PS", three instructions (4), (5) and (6) following instruction (3) are executed continuously.

Consequently, the program counter (PC) advances to NOP instruction (7) when the step operation is executed from the point of "POP PS" instruction (1).

Note:

- Issuing a chip reset during the execution of the user program, the following functions cleared.
  - Execution cycle measurement
  - Performance measurement
  - Data match status of Data watch break

2.6.5 To Access the Flash Memory

This section describes the access method to the flash memory in the MB2100-01 emulator debugger.

■ Access to Flash Memory

In this emulator debugger, the direct operation of the content of the flash memory can be done as well as RAM area.

■ What is flash memory synchronization?

When data is written into the flash memory, the data is stored temporarily. Subsequently, the contents of the flash memory need to be matched with each other with specific timing.

The matching operation is referred to as "flash memory synchronization" (or, "synchronization of flash memory").

There are two types of flash memory synchronization:

- Flash memory synchronization [Flash -> Debugger]
  Updates the contents of the flash memory.
- Flash memory synchronization [Debbuger -> Flash]
  Updates the stored data on the flash memory.

■ Methods of flash memory synchronization

Flash memory synchronization can be performed in either a manual or automatic method.

● Flash memory synchronization [Flash -> Debugger]

- Manual flash memory synchronization
  Select the [Environment] - [Flash area control] menu. For details, refer to "4.7.4 Flash area control" in "SOFTUNE Workbench Operation Manual".
- Automatic flash memory synchronization
  Flash memory synchronization is automatically performed if the target flash memory area is updated when carrying out one of the following operations.
  - Load the following files.
    Target file (Load module file)
    Binary file
  - Save the following files (specify name).
    Load module file
    Binary file
  - View the following windows
    Memory window
    Disassembly window
    Source window
    Trace window

- View the following dialogs.
  Line Assembly dialog (Disassembly window)
  Break setting dialog [Software]

● Flash memory synchronization [Debbuger -> Flash]

- Manual flash memory synchronization

  Select the [Environment] - [Flash area control] menu. For details, refer to "4.7.4 Flash area control" in "SOFTUNE Workbench Operation Manual".
- Automatic flash memory synchronization
  - When a user program has been executed
  - When a reset has been issued
  - When debugging has been ended
  - When the use of software break is set to prohibition
  - When the target file is automatically loaded at start of debugging

---

Note:

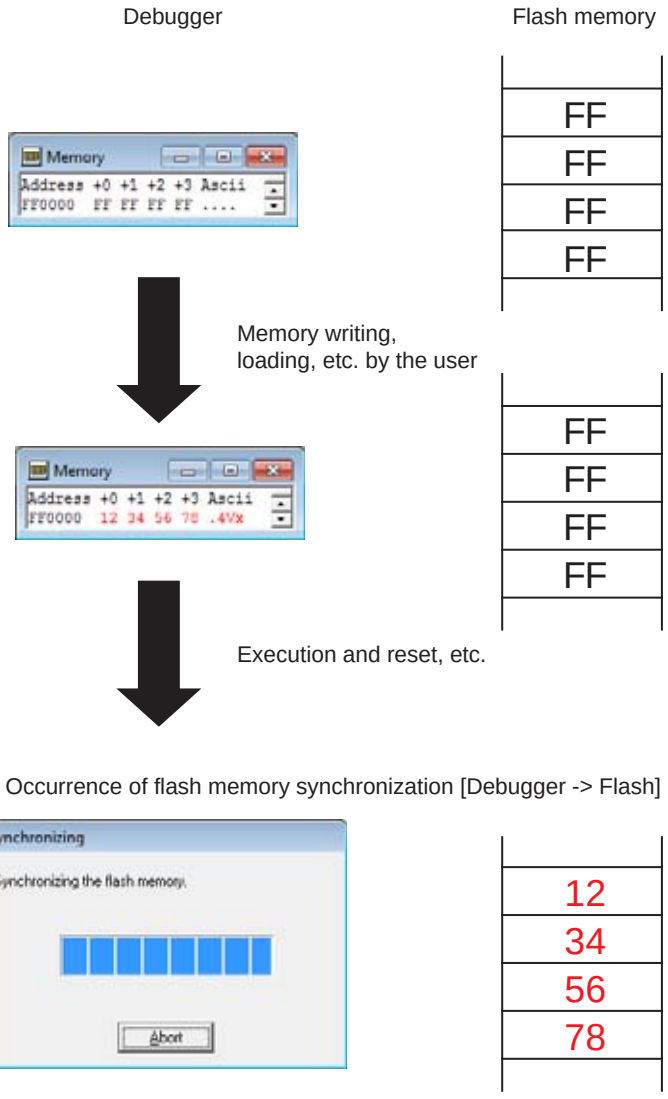
To shorten flash memory synchronization processing, set the communication speed of the debugger to the high-speed mode. For details, refer to "2.6.3.1 Increasing Communication Speed during Debugging".

■ Examples of flash memory synchronization

- In the case of [Debugger -> Flash]

An image in the case where the flash memory synchronization [Debugger -> Flash] has been performed is shown below.

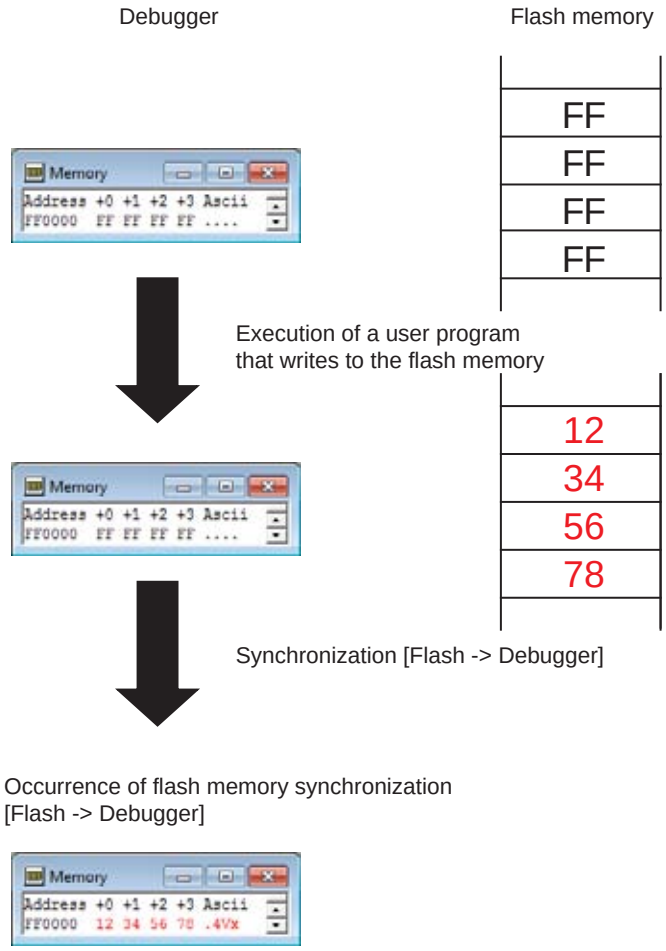
Variations in the values of the debugger and flash memory
in the case of the flash memory synchronization [Debugger -> Flash]



- In the case of [Flash -> Debugger]

An image in the case where the flash memory synchronization [Flash -> Debugger] has been performed is shown below.

Variations in the values of the debugger and flash memory
in the case of the flash memory synchronization [Flash -> Debugger]



Occurrence of flash memory synchronization
[Flash -> Debugger]

2.6.6 To Interrupt the Program Execution [Break]

This section describes the method of interrupting the execution of the user program in the MB2100-01 emulator debugger.

■ Break Functions

The function to interrupt the execution of the user program is called a break function.

This Emulator debugger provides the following seven types of break functions;

- Code break (hardware)
- Code break (hardware/count)
- Code break (software)
- Data break
- Forced break
- Data watch break
- Sequencer

When by each break function aborts program execution, the address where a break occurred and the break factor are displayed.

2.6.6.1 Code Break (Hardware)

This function suspends program execution by monitoring a specified address by hardware. A break occurs before an instruction at the specified address is executed.

■ Code Break (Hardware)

This function suspends program execution by monitoring a specified address by hardware. A break occurs before an instruction at the specified address is executed.

Code Break (Hardware) has the hardware/count for which a path count can be set.

The maximum number of points that can be set is as follows:

Hardware: 8 points

Hardware/count: 2 points

When the code break (hardware) occurs, the following message appears in the status bar.

- Hardware:
  Break at [Address] by code event break
- Hardware/count
  Break at [Address] by sequential or pass count break

■ How to set

Control the code break in the following methods:

- Command
  - SET BREAK/HARD
    Refer to "3.1 SET BREAK(type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - "Code" tab in the breakpoint setting dialog
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".
- Window
  - Source window/disassemble window
    Refer to "3.7 Source Window" or "3.9 Disassemble Window" in "SOFTUNE Workbench Operation Manual".

■ Special Operation when breakpoint is set

If the specified condition is satisfied in the debugger, note that the following phenomenon occurs.

- No progressing of program counter (PC)
  If the hardware break is set to the string instruction, the pass count may be added several times by one instruction execution.
  Furthermore, if program is executed from the string instruction which the hardware break is set, a break occurs without progressing PC.
- When the breakpoint is hit, the stopping address becomes after two instructions or less from the address that is sure to stop originally.
  During continuous user program execution, the address where the program stops becomes after two instructions or less from the address that is sure to stop originally when either of the following conditions was satisfied.

- When the break operation is generated while the instruction where the user interrupt is generated and the next one instruction or less are executed
- When the break operation is generated while either of the following instructions and the next one instruction or less are executed

  - INT addr16
  - INTP addr24
  - POPW PS
  - AND CCR #imm8
  - OR CCR #imm8
  - MOV ILM #imm8
  - Prefix codes (PCB, DTB, ADB, SPB, CMR, NCC)
  - INT9
  - INT #vct
  - JCTX @A
  - RETI
  - Undefined instructions (exceptions)

Notes:

- When setting a breakpoint, always specify the starting address of the instruction. A break may not occur if an address other than the starting address is specified.
- A code break shares points with the following functions. The maximum number varies depending on how those functions are used.
  - Data break
  - Data watch break
  - Sequence
- When hardware or hardware/count break is set at the top of the reset handler, the break does not occur.
- When the pass count mode is the passing count break mode, the hardware/count break cannot be used. For details, refer to "2.6.3.2 Switching Debug Function".

2.6.6.2 Code Break (Software)

This function suspends program execution by monitoring a specified address by software. A break occurs before executing an instruction at the specified address.

■ Code Break (Software)

This function suspends program execution by monitoring a specified address by software.

Setting area : RAM area or flash memory area

The break conditions : Before executing an instruction the specified address

The maximum number of points: 4096 points

When the code break (software) occurs, the following message appears in the status bar.

Break at [Address] by breakpoint

■ Operation Requirements

Please set the use of the software break to permission when you use the code break (software) by the following method. It is not possible to set it to not only the flash memory area but also RAM area when prohibiting it.

- Dialog
  - Setup wizard
    For details, refer to "4.7.2.5 Setup Wizard" in "SOFTUNE Workbench Operation Manual".
  - Debug environment setting dialog "Break" tab
    For details, refer to "4.7.2.3 Debug Environment" in "SOFTUNE Workbench Operation Manual".

■ How to set

Control the code break in the following methods:

- Command
  - SET BREAK/SOFT
    Refer to "3.1 SET BREAK(type1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - "Code" tab in breakpoint setting dialog
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".
- Window
  - Source window/disassemble window
    Refer to "3.7 Source Window" or "3.9 Disassemble Window" in "SOFTUNE Workbench Operation Manual".

Notes:

- When setting a code break (software) in a flash memory area, the contents of the flash memory at the specified address is temporarily rewritten. For details, refer to "2.6.5 To Access the Flash Memory".
- When the debugger has aborted in the state where the code break (software) is set, the contents of the flash memory can be abnormal. For details, refer to "2.6.2 Ending debugging".

2.6.6.3 Data Break

This function suspends program execution when data access (read/write) is made to a specified address.

■ Data Break

This function suspends program execution when data access (read/write) is made to a specified address. Up to 8 points can be set.

When the data break occurs, the following message appears in the status bar.

Break at [Address] by data event break

■ How to set

Control the data break in the following methods:

- Command
  - SET DATABREAK
    Refer to "3.9 SET DATABREAK (type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - "Data" tab in the breakpoint setting dialog
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".

Notes:

- A data break shares points with the following functions. The maximum number varies depending on how those functions are used.
  - Code break
  - Data watch break
  - Sequence
- The data break may stop after a few instructions following the instruction with detection access are executed.
- A data access in the string instruction is optimized in the chip. Therefore, the data break may not be detected in the specified condition.
- The data break may stop the program execution after a few instructions following the instruction with detection access are executed.

2.6.6.4 Forced Break

This function forcibly suspends program execution.

■ Forced Break

This function forcibly suspends program execution.

When the forced break occurs, the following message appears in the status bar.

Break at [Address] by command abort request

■ How to Generate

A forced break is generated in the following methods:

- Menu

  [Debug] - [Abort] menu

  Refer to "4.6.2 Abort" in "SOFTUNE Workbench Operation Manual".

- Command
  - ABORT

    Refer to "2.4 ABORT" in "SOFTUNE Workbench Command Reference Manual".

■ When a User Program does not Stop

In any one of the following, even when the forced break is caused to occur, the user program may not stop. Solutions are described below.

- The communication speed of the debugger is low.

  [Phenomenon] When the communication speeds of the debugger is low, it can take time to receive a program stop request.

  [Solution] Await for some time until receipt of the stop request is completed.

- The interrupt level is low.

  [Phenomenon] When the interrupt level of the program stop request is low, the interrupt is masked by the CPU interrupt level (ILM).

  [Solution 1] Alter the interrupt level of the stop request, and issue a stop request again.

  [Solution 2] Issue a program forced-stop request.

- The debugger is in power-on debugging.

  [Phenomenon] It is considered that the debugger is in power-on debugging.

  [Solution] Cancel the power-on debug mode.

- The MCU is in a hang-up state.

  [Phenomenon] It is considered that the MCU is in a hang-up state.

  [Solution] Issue a reset.

Note:

If the forced break is performed in CPU pause state a break occurs after that mode is released.

For more details, see "Appendix C. Debugger Suspension Messages" in "SOFTUNE Workbench Command Reference Manual".

2.6.6.5 Data Watch Break

This special break function suspends program execution when the program reaches a specified instruction address while the value in the specified data address matches with specified data.

■ Data Watch Break

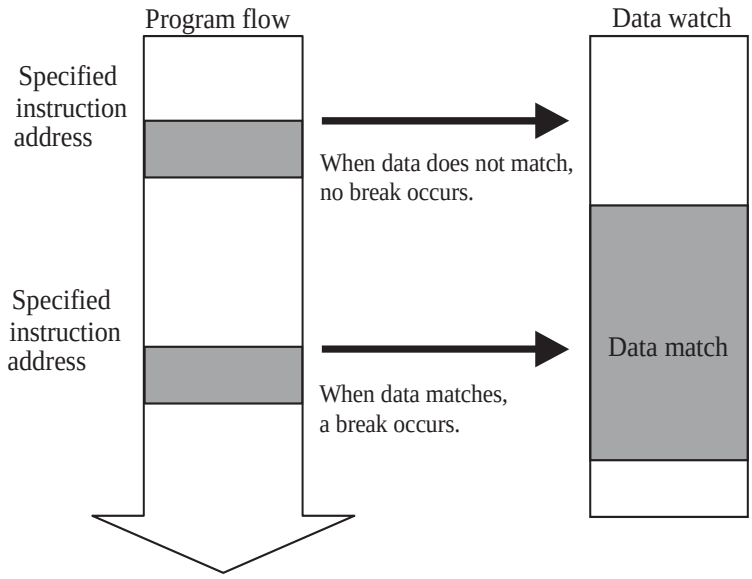
This special break function suspends program execution when the program reaches a specified instruction address while the value in the specified data address matches with specified data. Up to 2 points can be set.

The following message is displayed in the status bar, when a data watch break occurs.

Break at address by breakpoint (data watch)

The break conditions for the data watch break are illustrated in the Figure 2.6-3.

Figure 2.6-3 Break Conditions for Data Watch Break



■ How to set

Control the data watch break in the following methods:

- Data watch break
  - Command
    - SET BREAK/DATAWATCH
      Refer to "3.3 SET BREAK(type3)" in "SOFTUNE Workbench Command Reference Manual".
  - Dialog
    - "Code" tab in the breakpoint setting dialog
      "Hardware/data watch"
      Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".

Notes:

- A data watch break shares points with the following functions. The maximum number varies depending on how those functions are used.
  - Code break
  - Data break
  - Sequence
- The data watch break may stop if it hits a specified address after a few instructions following the instruction with data detection access are executed. Consequently, it may not stop if it hits the specified address during the execution of an instruction.
- If the instruction address of the data watch break is set to the string instruction, the program execution may not stop as expected.

2.6.6.6 Sequencer

A sequencer is a function to abort the program execution to the specified event condition when program passes the event following a certain flow (sequence).

■ Control by Sequencer

Table 2.6-2 shows the specifications of the sequencer function for this emulator debugger.

2 events are set and the level is passed through level 1 to level 2 in this order. This becomes sequencer termination condition. This sequencer is called a 2-level sequencer.

Furthermore, pass information up to that point is reset and an event for restart which monitors the passage of level 1 againg can be set.

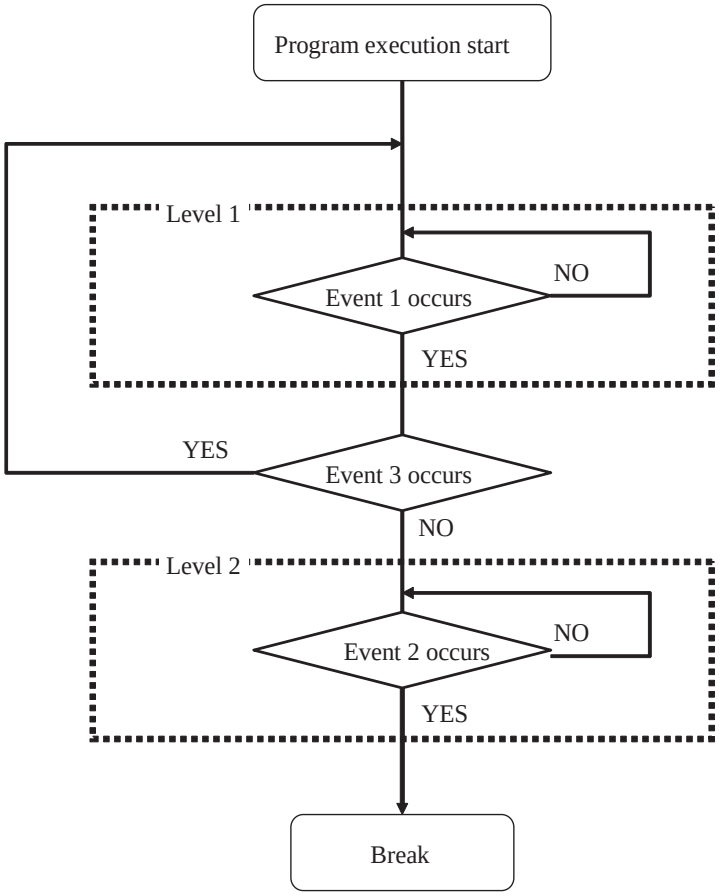
■ Operation of Sequencer

When events are set to each level as shown in example, the sequencer operates as shown in Figure 2.6-4.

[Example]

```
Level 1 : Event 1
Level 2 : Event 2
Restart : Event 3
```

Figure 2.6-4 Operation of Sequencer



■ Specifications of Sequencer

Table 2.6-2 shows the specifications of the sequencer for this emulator debugger.

Table 2.6-2 Specifications of Sequencer

Function	Specification
No. of levels	2 levels
Restart function	Available (one)
Conditions of each event (Code/data)	Address Pass count: 1 to 1048575 Attribute: Read/write Data size: Byte, Word, Long (Attribute and data size can be specified only for data events.)
Operation when conditions are met	Level 1: Moves to level 2 Level 2: Terminates the sequencer Restart: Starts the sequencer

■ How to set

Control the sequencer in the following methods:

● Sequencer

- Dialog
  - Select [Debug] - [Sequence] menu.
    For details, refer to "4.6.6 Sequence" in "SOFTUNE Workbench Operation Manual".
- Command

  1. The event is set according to the SET EVENT command.
  2. The event set by the SET SEQUENCE command is set as a sequence.

  For details, refer to "3.22 SET EVENT(type 2)" or "3.28 SET SEQUENCE (type2)" in "SOFTUNE Workbench Command Reference Manual".

Notes:

- When the pass count mode is a passing count break mode, this function cannot be used.
  For details, refer to "2.6.3.2 Switching Debug Function".
- Depending on the output timing of external trace data, the actual order of code execution may change places with the order of data hit information. For this reason, if a code event and a data event occur close to each other, normal transition may not occur.
- A sequencer shares points with the following functions. The maximum number varies depending on how those functions are used.
  - Code break
  - Data break
  - Data watch break
- If a data event is set to the sequencer, the data event may stop after a few instructions following the instruction with detection access are executed.
- If an event of the sequencer is set to the string instruction, the sequencer may not operate as expected by the following reason.
  - In code event
    The pass count may be added several times by one instruction execution.
  - In data event
    A data access in the string instruction is optimized in the chip.

2.6.7 Measuring the Program Execution Cycle Count

This section explains the function of measuring the number of program execution cycles.

■ Measurement Items

This function measures the number of program execution cycles.

The measurement is performed whenever a program is executed, and the measurement result displays the following two values:

- The number of execution cycles for the previous program execution
  The maximum number of cycles that can be measured is "2 to the power of 58 - 1", in other words, up to 288,230,376,151,711,743 cycles.
- The total number of execution cycles after the previous clear operation
  The maximum number of cycles that can be measured is "2 to the power of 64 - 1", in other words, up to 18,446,744,073,709,551,615 cycles.

■ Displaying Measurement Results

Either of the following methods can be used to display the measurement results.

- Display by dialog

  The results appear in the time measurement dialog, which can be displayed by selecting [Debug] – [Time Measurement] menu.

  For details, refer to Section "4.6.8 Time Measurement" in "SOFTUNE Workbench Operation Manual".
- Display by command

  Enter the SHOW TIMER command in the command window.

  For details, refer to Section "4.27 SHOW TIMER" in "SOFTUNE Workbench Command Reference Manual".

■ Clearing Measurement Results

Either of the following methods can be used to clear the measurement results.

- Clearing by dialog

  Click the [Clear] button in the time measurement dialog, which can be displayed by selecting [Debug] – [Time Measurement] menu.

  For details, refer to Section "4.6.8 Time Measurement" in "SOFTUNE Workbench Operation Manual".
- Clearing by command

  Enter the CLEAR TIMER command in the command window.

  For details, refer to Section "4.28 CLEAR TIMER" in "SOFTUNE Workbench Command Reference Manual".

■ Error Information

Click the [Comment] button in the time measurement dialog to display error information about the measurement results.

Notes:

- The number of cycles measured normally includes an error of about 10 cycles. However, it may be even more, depending on the bus state.
- If a chip reset is issued during debugging, the measurement cycle count is cleared.

2.6.8 Measuring Event-to-Event Execution Cycle Count [Performance Measurement]

This section explains how to measure the execution cycle count between two events in the MB2100-01 emulator debugger.

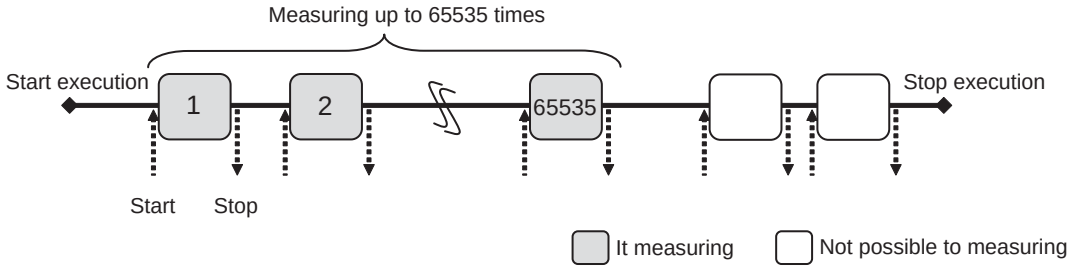
■ Performance Measurement

This emulator debugger measures the execution cycle count between two events, which the system has passed while a user program is running. This is referred to as "performance measurement".

The features for the performance measurement are as follows.

- Measuring the cycle count required to carry out the event-to-event execution
- Measuring up to 65535 times, using an event-to-event measurement as one cycle
- The allowable number of intervals is only one if one interval is required between two events.
- Accumulating the measurement result and obtaining the average value based on the measuring count

The following shows the performance measurement image.



■ Measurement Items

The measurement items for the performance function are as follows.

Cycle count : Accumulates the number of cycles required to carry out the event-to-event execution.
Measuring count : Accumulates the number of times the system passes from event to event.
Average : Average obtained by dividing the cycle count by the measuring count

■ Remeasuring

Remeasuring performance refers to a function that clears the measuring count during execution of a user program and remeasures from the beginning.

To carry out remeasuring, select [Restart] in the shortcut menu of the performance window.

If necessary, you can respecify the performance measuring interval (event) during execution.

This restarts measuring at the times when events have been set.

Notes:

- This function is not available when the execution time mode is set to the time measuring mode. For details, refer to Section "2.6.3.2 Switching Debug Function".
- If two triggers (start and end) specified as a measuring interval have occurred at the same time, performance measuring is not performed.
- An error of approximately 10 cycles is always detected each time a user program is re-executed because its execution has been stopped due to a breakpoint during performance measurement. The error may exceed 10 cycles depending on the bus state.
- If the performance measurement interval (event) is re-specified during execution of a user program, the previous measurement results are cleared.

2.6.8.1 Measuring Performance

This section explains how to measure the event-to-event execution cycle count in the MB2100-01 emulator debugger.

■ Measuring Procedure

Use the following steps to measure the performance.

1. Specify the performance measuring interval.
2. Execute the measurement.
3. Display the measurement result.

Each of these steps can be executed in two methods: using GUI (window or dialog) and using only the command. In both methods, the same measurement result is obtained.

● Using GUI for measuring

1. Display the performance window.
   - Select [View] - [Performance] menu.
     For details, refer to Section "3.18 Performance Window" in "SOFTUNE Workbench Operation Manual".
2. Specify the performance measuring interval.
   - Right-click on the performance window, and select [Setup] from the shortcut menu. The performance setting dialog appears.
     Here, click the [Display Range] tab to specify the interval in which performance is to be measured. For details, refer to Section "4.4.14 Performance" in "SOFTUNE Workbench Operation Manual".
3. Execute user programs.
4. Display the measurement result.
   - Right-click on the performance window, and select [Refresh] from the shortcut menu. The performance measurement result appears.

● Using Command for Measuring

1. Specify performance events.
   - Execute the SET EVENT command.
     For details, refer to Section "3.22 SET EVENT(type 2)" in "SOFTUNE Workbench Command Reference Manual".
2. Specify the performance measuring interval.
   - Execute the SET PERFORMANCE command.
     For details, refer to Section "4.9 SET PERFORMANCE (type 3)" in "SOFTUNE Workbench Command Reference Manual".
3. Execute user programs.
4. Display the measurement result.
   - Execute the SHOW PERFORMANCE command.
     For details, refer to Section "4.11 SHOW PERFORMANCE(type 1)" in "SOFTUNE Workbench Command Reference Manual".

■ Ending the Measurement

The performance measurement is ended in one of the following cases.

- The measuring count has reached 65535.
- A user program has stopped during measurement.

Notes:

- If [Refresh] is selected in the performance window during performance measuring, only the measuring count appears.
- Whether the performance measurement is currently being continued can be checked using the built-in variable "%GET_PERFORMANCESTATE".
  Refer to "14.25 %GET_PERFORMANCESTATE" of "SOFTUNE Workbench Command Reference Manual" for details.
- If the starting event and ending event of the performance measurement is set to the string instruction, the event is not detected correctly and the performance measurement may not operate as expected.

2.6.9 Viewing Program Execution History [Trace]

This section describes the trace function of this emulator debugger.

■ What is Trace

The function that records the program execution history is called "trace".

Trace data contains address information before and after branch, which is available for the analysis of the program execution history.

■ Trace Functions

This emulator debugger has the following trace functions.

- Forced start: Forcibly starts acquiring trace data without stopping the execution of a user program while forced stop is executed and trace data acquisition is stopped.
- Forced stop: Forcibly ends acquiring trace data without stopping the execution of a user program during acquisition of trace data.

■ Acquiring Trace Data

The trace data acquisition is started and ended at the following times.

● The acquisition is started when:

- a user program has been executed; or
- the [Start] menu has been selected when a user program has been executed.

● The acquisition is ended when:

- a user program has been stopped; or
- the [Abort] menu has been selected during trace data acquisition.

■ Trace Buffer

A place to store recorded data is called a "trace buffer".

Each unit of data stored in the trace buffer is called a "frame".

The trace buffer can contain up to 1,024 frames.

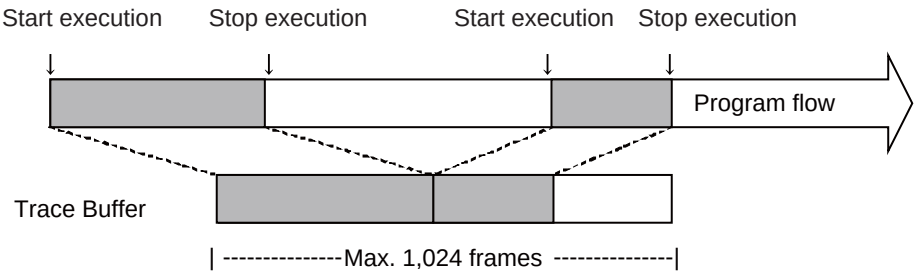
The trace buffer has a ring-like structure. If the trace buffer becomes full, it is automatically overwritten from the beginning.

Figure 2.6-5 shows how data is stored in the trace buffer.

- When break halts program execution

Figure 2.6-5 Acquiring Trace Data

When a break occurred during execution of a program



Note:

Executing the forced start will clear the trace data that was stored until then.

2.6.9.1 Displaying Trace Data

This section explains how to display trace data.

■ Display Formats of Trace Data

The following three formats can be used to display trace data.

RAW data:	Displays trace data without analyzing it.
Instruction:	Displays trace data in the order in which instructions are executed.
Source:	Displays trace data on a source line basis.

■ Trace Data Display Position

Sampled trace data is numbered by frame. This number is called a "frame number".

When displaying trace data, the starting location in the trace buffer can be specified using the frame number.

Ordinarily, the last sampled trace data is assigned to frame number 0.

■ How to Display Trace Data

Trace data is displayed in the trace window or command window.

The following two display methods are available, both of which enable you to obtain the same result.

● Using trace window

1. Display the trace window.
   - Select [View] - [Trace] menu.
2. Select the display mode of the trace window.
   - Right-click on the trace window, and select [RAW data], [Instruction], or [Source] from the shortcut menu.
     For details, refer to Section "3.14 Trace Window" in "SOFTUNE Workbench Operation Manual".
3. (If the trace window is already displayed), update trace data.
   - Right-click on the trace window, and select [Refresh] from the shortcut menu. Trace data is updated in the trance window.
     For details, refer to Section "3.14 Trace Window" in "SOFTUNE Workbench Operation Manual".

- Using command window

  1. Display trace data for each display mode.

     RAW data: SHOW TRACE

     Instruction: SHOW TRACE

     Source: SHOW TRACE

     For details, refer to Section "4.32 SHOW TRACE (type 2)" in "SOFTUNE Workbench Command Reference Manual".

Note:

In the disassembly format, data is read from memory to be displayed. If an instruction is rewritten after code fetching, data will not be displayed correctly.

2.6.9.2 Trace Data Display Examples (RAW Data)

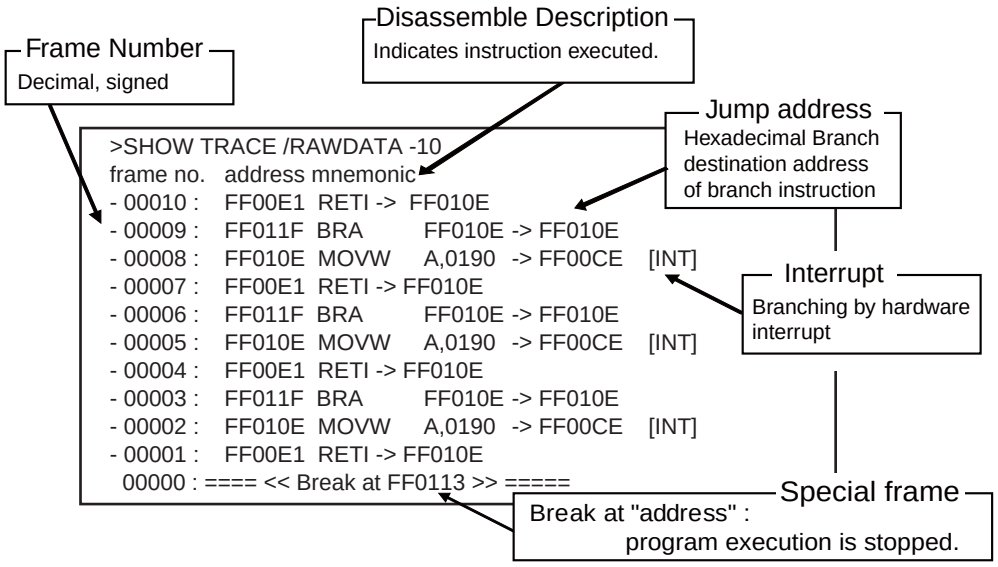
This section describes trace data that is displayed in the RAW data mode.

■ RAW Data Display

This format displays frames that are output from the emulator without analyzing them.

Figure 2.6-6 shows a RAW data display example.

Figure 2.6-6 Example of the RAW Data Display



frame no.

Displays frame numbers in decimal notation.

address

Displays a branch address.

Branch destination address = 110C6:"-> 000110C6"

Branch source address = 110A8:"000110A8 ->"

mnemonic

Displays the instructions that are executed.

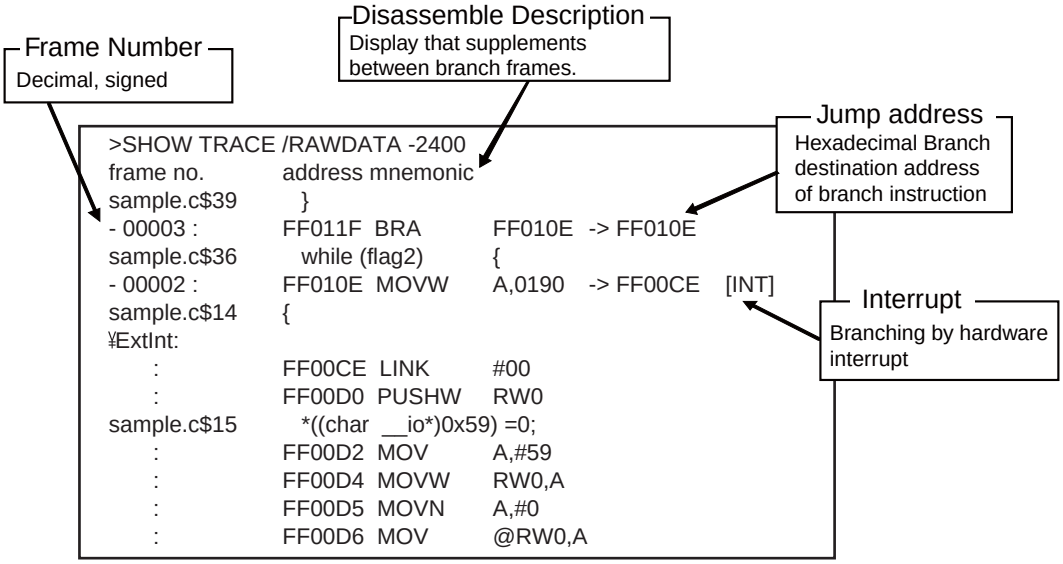
2.6.9.3 Trace Data Display Example (Instruction)

This section describes trace data that is displayed in the instruction mode.

■ Instruction Display

This mode displays the branch addresses of the RAW data display in disassembly format. Figure 2.6-7 shows an instruction display example.

Figure 2.6-7 Example of the Instruction Display



frame no.

Displays the frame number in decimal form.

address

Displays the branch addresses.

mnemonic

Displays disassembly of the instructions that are executed between branch addresses.

Note:

For branch addresses (b-addr), an instruction between the branch addresses is extracted to get the frames to complement each other by disassembly. When they are complemented, the frame number field is blank.

2.6.9.4 Trace Data Display Example (Source)

This section describes trace data that is displayed in the source line mode.

■ Source Display

This mode displays only source lines. Figure 2.6-8 shows a source display example.

Figure 2.6-8 Example of the Trace Data Display (Source)

```
>SHOW TRACE/SOURCE -10..-5
frame no.     source
        :     sample.c$61                    if (p->val >= tblp[j - 1]->val)
-00007  :     sample.c$62                        break;
        :     sample.c$66           tblp [i - 1] = p;
-00006  :     sample.c$67     }
        :     sample.c$53     while (max > 1) {
        :     sample.c$54           p = tblp [max - 1];
        :     sample.c$55           tblp [max - 1] = tblp[0];
        :     sample.c$56           max--;
        :     sample.c$57           i = 1;
```

frame no.

Displays frame numbers as decimal number.

source

Displays the source line to be executed.

2.6.9.5 Saving Trace Data

This section explains how to save trace data.

■ Saving Trace Data

Trace data can be saved in a specified file.

The following two methods are available to save trace data: using GUI (window or dialog) and using only the command. The same result is obtained from both methods.

● Using GUI for Saving Trace Data

1. Display the trace window.
   - Select [View] - [Trace] menu.
2. Specify the name of the file in which to save trace data.
   - Right-click on the trace window, and select [Save] from the shortcut menu. The [Save as] dialog appears.
     Specify the file name and where to save trace data. For details, refer to Section "4.4.8 Trace" in "SOFTUNE Workbench Operation Manual".

● Using Command for Saving Trace Data

1. Save trace data.
   - Execute the SHOW TRACE/FILE command.
     For details, refer to Section "4.33 SHOW TRACE (type 3)" in "SOFTUNE Workbench Command Reference Manual".
     When additionally saving trace data in an existing file, execute the SHOW TRACE/FILE/APPEND command.

2.6.9.6 Searching for Trace Data

This section explains how to search for trace data.

■ Searching for Trace Data

The specified address or frame number in trace data can be displayed.

The following two methods are available to search for trace data: using GUI (window or dialog) and using only the command. The same result is obtained from both methods.

● Using GUI for Searching for Trace Data

1. Display the trace window.
   - Select [View] - [Trace] menu.
2. Specify the address or frame number to search for trace data.
   - Right-click on the trace window, and select [Find] from the shortcut menu. The trace data search dialog appears.
     Specify the address or frame number to be displayed. For details, refer to Section "4.4.8 Trace" in "SOFTUNE Workbench Operation Manual".

● Using Command for Searching for Trace Data

1. Search for trace data.
   - Execute the SEARCH TRACE command.
     For details, refer to Section "4.37 SEARCH TRACE" in "SOFTUNE Workbench Command Reference Manual".

Note:

Trace data can search only branching source address.

2.6.10 How to Display the Output Message from User Program to the Debugger

This section explains the semihosting feature of MB2100-01 emulator debugger.

■ What is Semihosting Feature

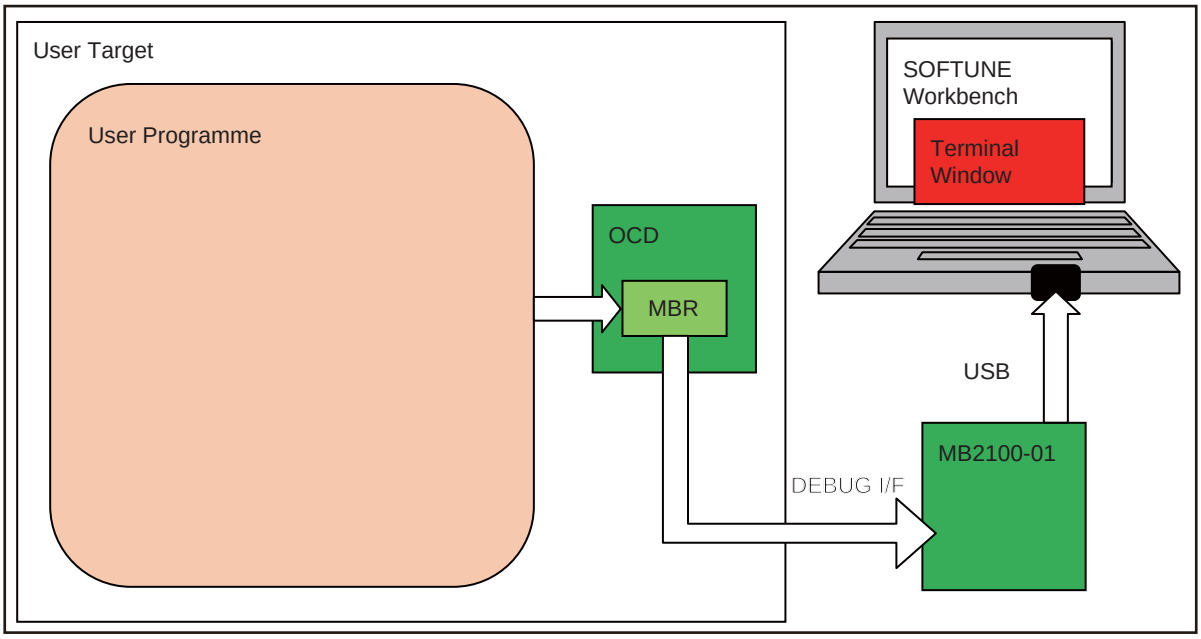
The semihosting feature is a function to display a message output by the user program on the debugger window.

As shown in Figure 2.6-9, when receiving an output request to the message buffer register (MBR) on debug I/O, the debugger displays the output content on the window by receiving the content.

In this case, data from the user program to the debugger is output via DEBUG I/F from MBR according to the arrow in Figure 2.6-9.

For details of on-chip debugger (OCD) and MBR, refer to the hardware manual.

Figure 2.6-9 Data Flow in Semihosting Feature



■ What is Terminal Window

Terminal window is the window displaying data when receiving an output request from user program to MBR. Refer to section "3.22 Terminal Window" of "SOFTUNE Workbench Operation Manual" for details of terminal window.

The data output to the terminal window is interpreted and output as ASCII characters. However, the supported control characters are'\n', '\r' and '\t'. The other control characters and the characters after 0x80 are output as '.'.

The terminal window will appear when the data to be displayed is acquired.

■ Using Method of Semihosting Feature

Use the following procedure to display the content of the output request to MBR on the terminal window.

1. Control MBR in the user program.
   As shown in Figure 2.6-9, it is necessary to control MBR in the user program.
   Sample project including the control method of MBR is attached in SOFTUNE Workbench V30L36 or later. Control MBR based on this. For details, refer to "APPENDIX J Sample Project for Semihosting Feature" in "SOFTUNE Workben ch Operation Manual".
2. Display the content of the output request to MBR on the terminal window.
   Use the following method to display the terminal window.
   The following two methods are available to display the content of the output request: using GUI (window) and using the command. The same result is obtained from both methods.
   - Display by window
     - The content is displayed in the terminal window selected by [View] - [Terminal] menu. For details, refer to section "3.22 Terminal Window" in "SOFTUNE Workbench Operation Manual".
   - Display by command
     - Enter the SET LOGGING/TERMINALWINDOW command in the command window. For details, refer to section "11.1 SET LOGGING" of "SOFTUNE Workbench Command Reference Manual".

2.6.11 Checking Debugger Information

This section explains how to check information about the MB2100-01 emulator debugger.

■ Debugger Information

This emulator debugger enables you to check the following information at startup.

- SOFTUNE Workbench file information
- Hardware information

If any errors have been discovered during SOFTUNE Workbench operations, check this information and contact our sales department or support department.

■ How to Check

Use one of the following methods to check debugger information.

- Command
  - SHOW SYSTEM
    Refer to Section "1.19 SHOW SYSTEM" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Version information dialog
    Select [Help] - [Version Information] menu.
    For details, refer to Section "4.9.3 Version Information" in "SOFTUNE Workbench Operation Manual".

■ Displayed Contents

```
F2MC-16 Family SOFTUNE Workbench VxxLxx
ALL RIGHTS RESERVED,
  COPYRIGHT(C) FUJITSU SEMICONDUCTOR LIMITED 1997
LICENCED MATERIAL -
  PROGRAM PROPERTY OF FUJITSU SEMICONDUCTOR LIMITED
=======================================================
Cpu information file path: CPU information file path
Cpu information file version: CPU information file version
=======================================================
Add in DLLs
-------------------------------------------------------
 SiCmn
 Product name: SOFTUNE Workbench
 File Path: SiC907.dll path
 Version: SiC907.dll version
- - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 SiiEd
 File Path: SiiEd3.ocx path
 Version: SiiEd3.ocx version
-------------------------------------------------------
 SiM907
 Product name: SOFTUNE Workbench
 File Path: SiM907.dll path
 Version: SiM907.dll version
- - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Language Tools
 - F2MC-16 Family SOFTUNE C Compiler version
   File Path:  fcc907s.exe path
 - F2MC-16 Family SOFTUNE Assembler version
   File Path:  fasm907s.exe path
 - F2MC-16 Family SOFTUNE Linker version
   File Path:  flnk907s.exe path
 - F2MC-16 Family SOFTUNE Librarian version
   File Path:  flib907s.exe path
 - SOFTUNE FJ-OMF to S-FORMAT Converter version
   File Path:  f2ms.exe path
 - SOFTUNE FJ-OMF to INTEL-HEX Converter version
   File Path:  f2is.exe path
 - SOFTUNE FJ-OMF to INTEL-EXT-HEX Converter version
   File Path:  f2es.exe path
```

```
 - SOFTUNE FJ-OMF to HEX Converter version
   File Path:  f2hs.exe path
-------------------------------------------------------
 SiOsM
 Product name: Softune Workbench
 File Path: SiOsM907.dll path
 Version:  SiOsM907.dll version
-------------------------------------------------------
 F2MC-16 Series Debugger DLL
 Product name: SOFTUNE Workbench
 File Path: SiD907.dll path
 Version:  SiD907.dll version
- - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Debugger type         : Current debugger type
MCU type              : Currently selected target MCU
VCpu dll name         : Path and name of the currently used VCpu dll
VCpu dll version      : Version of the currently used virtual debugger DLL
SiDRVo dll version    : Version of the currently used MB2100-01 driver DLL
DSU type              : Currently used DSU type
Adapter version       : Adapter version
FPGA version          : FPGA version
Maker ID              : ID that indicates the device manufacturer
CPU family ID         : ID that indicates the CPU family installed in the device
DSU type ID           : ID that indicates the OCD-DSU installation type.
DSU version ID        : ID that indicates version information of the DSU installed in the device
Device ID             : ID that indicates device information
Device version ID     : ID that indicates device version
OSC clock             : Oscillator frequency
PLL clock             : Reference clock frequency for high-speed communication
Clock mode            : Clock mode [Main/ Sub/ PLL]
Communication mode    : Communication mode
Communication device  : Device type
REALOS version        : REALOS version
-------------------------------------------------------
 SiIODef
 Product name:  Softune Workbench
 File Path:  SiIODef.dll path
 Version:  SiIODef.dll version
=======================================================
Current path:  Path of the currently used project
Language:  Currently used language
Help file path:  Help file path
================================================================================
```

2.7 Monitor Debugger

This section describes the functions of the monitor debugger.

■ Monitor Debugger

The monitor debugger performs debugging by putting the target monitor program for debugging into the target system and by communicating with the host.

Before using this debugger, the target monitor program must be ported to the target hardware.

2.7.1 Resources Used by Monitor Program

The monitor program of the monitor debugger uses the I/O resources listed below. The target hardware must have these resources available for the monitor program.

■ Required Resources

The following resources are required to build the monitor program into the target hardware.

Table 2.7-1 Resources Used by Monitor Debugger

1	UART	Necessary	For communication with host computer 4800/9600/19200/38400 bps
2	Monitor ROM	Necessary	Need about 10 KB (For details, refer to link map.)
3	Work RAM	Necessary	Need about 2 KB (For details, refer to link map.)
4	External-interrupt switch	Option	Uses for forced abortion of program. When the switch is not built-in, the program can stop at the breakpoint only.
5	Timer	Option	Uses for SET TIMER/SHOW TIMER . Needs 32 bits in 1 μs units.

2.7.2 Break

In the monitor debugger, two types of break functions can be used. When the program execution is aborted by each break function, the address and the break factor to do the break are displayed.

■ Break Functions

In this monitor debugger, the following two types of break functions are supported.

- Software break
- Forced break

2.7.2.1 Software Break

It is a function to bury the instruction for the break under the memory, and to do the break by the instruction execution. The break is done before an instruction the specified address is executed.

■ Software Break

It is a function to bury the instruction for the break under the memory, and to do the break by the instruction execution. The break is done before an instruction the specified address is executed.

The number that can be set is 16 points.

When a break occurs due to a software break, the following message is displayed on the status bar:

Break at Address by breakpoint

■ Setting Method

The software break is controlled by the following method.

- Command
  - SET BREAK/SOFT
    Refer to "3.1 SET BREAK (type 1)" in "SOFTUNE Workbench Command Reference Manual".
- Dialog
  - Breakpoint Set Dialog [Code] tab
    Refer to "4.6.4 Breakpoint" in "SOFTUNE Workbench Operation Manual".
- Window
  - Source window/Disassembly window

Note:

There are a couple of points to note when using software breaks.

- Software breaks cannot be set in an area that cannot be written, such as ROM. If attempted, a verify error occurs at starting the program (when continuous execution, step execution, etc., started).
- Always set a software break at the instruction starting address. If a software break is set in the middle of an instruction, it may cause a program null-function.

2.7.2.2 Forced Break

It is a function to abort the execution of the program compulsorily.

■ Forced Break

It is a function to abort the execution of the program compulsorily.

When a break occurs due to a forced break, the following message is displayed on the Status Bar.

Break at Address by command abort request

INDEX

The index follows on the next page.
This is listed in alphabetic order.

Index

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F^2MC-16 FAMILY

SOFTUNE™ Workbench

USER'S MANUAL

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